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NOTES ON SOME REMARKABLE AUSTRALASIAN WALKINGSTICKS, INCLUDING A SYNOPSIS OF THE GENUS EXTATOSOMA

(Orthoptera: Phasmatidae)

ASHLEY B. GURNEY

Bureau of Entomology and Plant Quarantine,
Agricultural Research Administration,
United States Department of Agriculture

This paper presents notes and photographs of species belonging to four of the more striking genera of Australasian walkingsticks, and it is hoped that some of the material contained may be of interest to general entomologists and teachers.

A few records regarding the largest known Phasmatidae may be presented here. The largest, which likewise have the greatest body length of living insects, belong to the genus *Pharnacia* and inhabit Borneo. Redtenbacher (1908) cites a female of *P. serratipes* (Gray) measuring 330 mm. (13 inches); Kirby (1896) recorded one of the same species as 12¾ inches long, but later (1904) referred his specimen to *P. maxima* (Bates). A female from Borneo in the United States National Museum, probably of one of the above species, is 11 inches (279.4 mm.) long. Gunther (1943, p. 155) recorded a Bornean female of *Pharnacia sagitta* Redt. 280 mm. long. The taxonomy of the species referred to *Pharnacia* is in a confused state, and species now assigned to the genus *Phobaeticus* are also involved. Chopard (1938, p. 20; 1945, p. 31) refers to species of *Phobaeticus* 300 mm. or more in length. Karny (1914, p. 9) has discussed several walkingsticks which attain a length of approximately one foot. So far as known, the smallest walkingsticks belong to the genus *Timema*, a male of *T. californicum* Sc. having been recorded by Hebard (1920a) as 12.5 mm. long.

The largest walkingstick living in the United States is *Megaphasma denticrus* (Stal), females of which reach 150 mm. in body length (see Hebard, 1943, p. 309). A female of that length from Musson, La., is in the National Museum. At the other extreme in the size of adult Orthoptera, Hebard (1920, p. 109) records a male of the cricket

Myrmecophila nebrascensis Lugger from Arizona as 1.3 mm. long, but the specimen may have been imperfect as he says (p. 94) that a depauperate specimen of *nebrascensis* 1.47 mm. long is the smallest adult orthopteron known to him. Smaller species occur in several orders of insects, particularly in the Hymenoptera, Coleoptera, Diptera, Homoptera, and Corrodentia.

A specimen (figs. 1, 2) of *Extatosoma popa* Stal, collected by a member of the armed forces in New Guinea, supplied the original incentive for gathering these notes, and this fact suggests that entomologically minded service men may find represented here certain of the forms encountered during overseas travels.[1]

Of the four genera treated, two (*Extatosoma, Dryococelus*) are given complete systematic coverage; but only general features or those of biological interest of the other two (*Cotylosoma, Eurycantha*) are discussed. *Cotylosoma* is one of the phasmatid[2] genera for many years erroneously supposed to be aquatic. The four genera do not of themselves constitute a natural group, though all belong to the subfamily Cladoxerinae (Phibalosomini of Redtenbacher), and *Dryococelus* and *Eurycantha* are closely related members of the Group Eurycanthae. *Dryococelus* is a new genus based on *Karabidion australe* Mont. The genus *Karabidion* has been found to be a synonym of *Eurycantha*, and the nomenclatorial matters involved are herein discussed under *Dryococelus*.

Genus **Extatosoma** Gray

Extatosoma Gray, 1833, Ent. Australia, pt. 1, Phasma, p. 23. Genotype, *Phasma tiaratum* W. S. MacLeay, 1826. (Selected by Kirby, 1904.)
Ectatosoma Gray, 1835, Synopsis Phasmidae, p. 29. (Emendation for *Extatosoma*).

Generic description (adapted with modifications from Westwood, 1859, p. 170)—Body large and spinose, the male winged, female brachypterous; certain middle segments of the abdomen of both sexes with lateral tergal lobes, these much more expanded in female than in male. Head prognathous, dorsal apex conical and spinose; ocelli distinct in male, lacking or evanescent in female; antennae simple, moderately pubescent. Mesothorax dilated posteriorly, less than twice prothoracic length. Tegmina of both sexes abbreviate, those of female somewhat broader than those of male; wings of male extending about to or beyond apex of abdomen, of female abbreviate, sometimes

[1]William J. Baerg, of the University of Arkansas, kindly made a specimen of *Extatosoma popa* available for study, and specimens located at the Academy of Natural Sciences of Philadelphia and the Museum of Comparative Zoology were studied through the kindness of James A. G. Rehn and John W. H. Rehn, and Joseph Bequaert, respectively, to whom I am particularly indebted for their cooperation. All photographs were made by Marcel L. F. Foubert, of the U. S. Department of Agriculture, whose skilled and careful work is demonstrated on the accompanying plates. The Linnean Society of New South Wales has kindly given permission to reproduce a photograph of *Extatosoma elongatum* Froggatt. Plates IV and VII were made from specimens belonging to the Academy of Natural Sciences of Philadelphia.

[2]The family name of the walkingsticks is considered to be Phasmatidae, derived from the stem of *Phasma*, as explained by Roberts (1944, p. 16), rather than the better known name Phasmidae. Descriptions of body spination utilize some of the names for standard body spines proposed as a system of acanthotaxy by Rehn and Rehn (1939).

shriveled and rudimentary. Legs moderately long to short; femora and tibiae spinose, trigonate, broadly dilated, more markedly so in female; ventral surface of middle and hind tibiae without apical triangular area, bearing apical hooked spine; basitarsus somewhat shorter than remaining tarsal segments. Ovipositor sheath of female boat-shaped and extending posteriorly beyond apex of abdomen; ovipositor valves long, filamentous, apically curved.

There is little likelihood of confusing the very distinctive females with those of any other genus. Males superficially suggest several genera, but may be assigned to *Extatosoma* by habitus and the combination of the foregoing characters. The relative scarcity of males may have prevented any large amount of misplacement of this sex in the past. Brullé (1836, p. 113) treated *Ectatosoma* as a synonym of *Tropidoderus* Gray 1835, a valid and very distinctive Australian genus.

The name *Extatosoma* is from two Greek words meaning, "capable of extension" and "body."

Distribution of genus—New Guinea, Australia, Lord Howe Island.

Since the male of only one species (*tiaratum*) is known, the following key includes only females.

KEY TO THE SPECIES OF EXTATOSOMA (FEMALES)

1. Fifth, sixth and seventh terga bearing lateral expansions which overlap when seen in dorsal view (fig. 1)..... 2
   Fifth, sixth and seventh terga bearing much smaller, non-overlapping expansions (fig. 4).....**elongatum**
2. A conspicuous V-shaped pale mark on mesonotum (fig. 1); metanotum and first tergum each with a pair of erect, well-developed lamellae (fig. 2); dorsal lamellae of fifth and sixth terga each occupying about one-third the length of segment, the base of each scarcely wider than apex and not extending in front of middle of segment; a compound lamellate spine on mesonotum between bases of tegmina.....**popa**
   No V-shaped pale mark on mesonotum; median lamellae of metanotum and first tergum absent or weakly developed, spines occurring there either separate or weakly confluent basally; dorsal lamellae of fifth and sixth terga extending in front of middle of segment, the base of each lamella wider than the apex (fig. 3); spines at base of mesonotum individual.....**tiaratum**

Westwood (1874, p. 174, pl. 32, figs. 2, 2a) described *Extatosoma bufonium* from Australia with no specific locality mentioned. The material, deposited in the Hope Collection at Oxford, consists of a single specimen 1¾ inches long. Rainbow (1897), Kirby (1904, p. 381) and Tepper (1903, p. 283) have merely cited *bufonium*, and Redtenbacher (1908, p. 381) and Froggatt (1922) have observed that the type specimen is immature and of uncertain position. A female nymph of *tiaratum* from New South Wales, which is 1¾ inches long, differs noticeably from Westwood's clearly drawn figures of *bufonium*. The specimen figured likewise differs from male nymphs of *tiaratum* examined which range from 37 mm. to 65 mm. in length. The figures are much more suggestive of *elongatum* than of *tiaratum*, but may not even represent this genus and so for the present *bufonium* remains unplaced. Study of a series of *elongatum* nymphs, should they become available, might add information, perhaps showing the latter name to be a synonym of *bufonium*.

Extatosoma tiaratum (W. S. MacLeay)

Figures 3, 5

Phasma tiaratum W. S. MacLeay, 1826,[3] Insects in: King's Narr. Surv. Coasts Australia, 2, p. 455, Tab. B, figs. 3, 4.

Extatosoma Hopei Gray, 1833, Ent. Australia, pt. 1, Phasma, p. 25. (As *E. Hopii*, ibid., p. 23.)

Descriptive notes (female)—Ocelli indicated by slight swellings, covered by integument; head conspicuously spined, about four pairs of spines of occipital medial series and same number of supraorbitals may or may not be present; a small, basally lamellate compound spine at each side of occipital crest; two pairs of median coronals posterior of crest; antennae simple, moderately long.

Pronotum elongate-rectangular, slightly rounded posteriorly; spination variable in size and number, anterior laterals present, also about three pairs anterior mesals, three pairs interposteriors and a pair of posterior medials. Mesonotum with well-developed pair of premedians, 4–6 laterals, and a pair of simple interposterior mesonotals between tegminal bases. Tegmina and wings essentially as in *elongatum* (fig. 4), wings sometimes not exceeding apices of tegmina. Simple median spines of metanotum and first tergum present, sometimes weakly confluent to make small lamellae. Abdomen usually robust, somewhat depressed; lateral expansions of fifth, sixth and seventh terga overlapping as in *popa* (fig. 1), development averaging smaller than in that species; spination following same pattern as in *popa* and *elongatum:* dorsal lamellae of fifth and sixth terga (fig. 3) recumbent or semierect. Legs with expansions much as in *popa*, development averaging smaller; tibial expansions occasionally bilobed, those of front tibiae often strongly so.

Coloration: General color in life dark green with grayish mottled areas, especially laterally. Preserved specimens varying shades of brown, tegmina and wings usually a dull green. Froggatt (1922) reported two bright yellow females, considered by him a remarkable variation.

Measurements: Body length said by Froggatt (1905) to reach 5 inches. Representative specimen (length): Body (head to apex of ultimate tergum), 110 mm.; front femur, 26 mm.; hind femur, 30 mm.; hind tibia, 30 mm.; pronotum, 9.5 mm.; mesonotum, 15 mm.; tegmen, 16 mm.; wing, 18 mm.; ovipositor sheath, 22 mm.

Male fig. 5—Three ocelli raised in a conspicuous cluster; head with strong trigonal spine each side of occipital crest, one pair of rudimentary median coronals posterior of crest, otherwise unspined; antennae simple, the segments weakly clavate. Pronotum with only

[3]The title page of this work bears the date 1827, which has usually been credited to it, but Austen (Ann. and Mag. Nat. Hist., (8), vol. 13, pp. 265–266, 1914) states that he was informed by C. Davies Sherborn that the work was actually issued April 18, 1826.

EXPLANATION OF PLATE I

FIGURE 1. *Extatosoma popa* Stal, female, dorsal view. Buna, N. E. New Guinea, December, 1943. Body length, 125 mm.

1.

rudimentary spines; wider than anterior margin of mesonotum. Mesonotum with pair of erect, elongate, premedian mesonotals one-third mesonotal length from anterior margin; otherwise unspined. Terga unspined; lateral expansions well developed on tergum 6, weak on 5 and 7. Ultimate tergum apically truncate, strongly convex, in lateral view seen to possess a strong lateral carina on each lateral half extending ventroposteriorly to posterior margin. Metasternum and abdominal sterna 2 and 3 strongly spined. Three segments of poculum[4] increasing regularly in size posteriorly, the ultimate segment in lateral view triangularly produced ventroposteriorly. Each cercus swollen in apical half, tapering from there to the apex and weakly flattened. Legs with lateral expansions developed to a lesser degree than in female. Wings as illustrated.

Coloration: According to Gray (1833,) the tegmina and costal margins of wings are green, the anal field of wing is blackish, with transverse irregular white bands; the abdomen is brownish green; the legs green with blackish, narrow, transverse bands. The general color of the dried alcoholic males examined is light brown.

Measurements (length): Body, 83 mm.; front femur, 22 mm.; hind femur, 22 mm.; hind tibia, 21 mm.; pronotum, 6 mm.; mesonotum, 8 mm.; tegmen, 18.5 mm.; wing, 73 mm.

Nymph (female)—Only specimen examined 48 mm. in length. Form very much like adult. Compound spines of occipital crest, premedian mesonotals, lateral expansions of fifth, sixth and seventh terga, paired median dorsal lamellae of fifth and sixth terga, and expansions of femora and tibiae strongly developed and essentially as in adult; paired median dorsal lamellae of metanotum and terga 1–4 more conspicuously developed than in adult, that of first tergum largest though only two-thirds the size of that of fifth tergum. Color in life apparently green.

Nymph (male)—Four specimens ranging from 37 mm. to 65 mm. in body length examined. Form much as in adult. Occipital spines, those of mesonotum, and expansions of femora and tibiae well developed; well formed tegminal and wing pads.

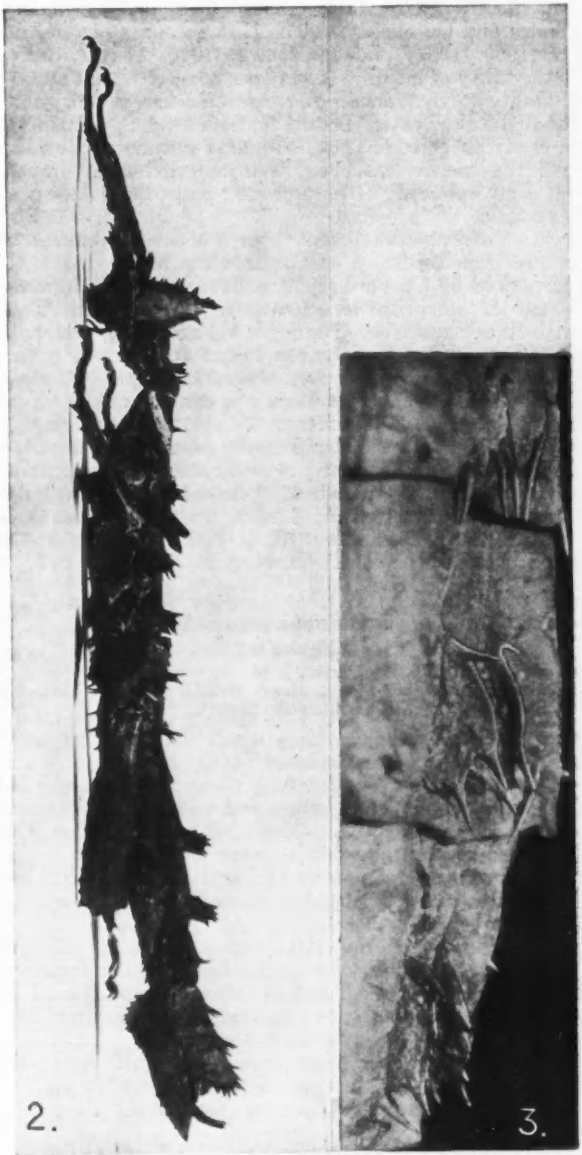
The association of the male (upon which the names *Hopii* and *Hopei* were based) and female was first recognized by Burmeister (1838, p. 576), suggested by Serville (1839, p. 287), and followed by subsequent authors. This insect has been cited as occurring from New Guinea to Tasmania, but Froggatt (1922) says that it is not known south of New South Wales. New Guinea records may all date back to Haan (1842) who identified as *tiaratum* the species later described as *popa*, particularly as the Haan record is repeated in uncorrected form in Rainbow's 1897 catalogue. Redtenbacher (1908) and Gunther (1932, pp. 782, 790, 825) list *tiaratum* from Lord Howe Island, although

[4]See Rehn and Rehn, 1939, footnote, p. 412.

EXPLANATION OF PLATE II

FIGURE 2. *Extatosoma popa* Stal, female, lateral view. Same specimen as in figure 1.

FIGURE 3. *Extatosoma tiaratum* (W. S. MacLeay), female, lateral view of fourth, fifth and sixth terga. New South Wales.


2.
3.

it was not mentioned by Olliff (1889). It is fairly common in New South Wales and Queensland. The best accounts of *tiaratum* are by Froggatt (1905, 1907) and McKeown (1940, 1944). Both authors mention the rarity of males. It has been suggested that males, because of their ability to fly, remain in trees some height from the ground, while the flightless, heavily bodied females tend to remain low where they are easily collected. The food plants include various shrubs and trees, and the species has even been collected from orchard peach trees, but a critical study of its preferred host plants does not seem to have been made.

Froggatt found about 100 eggs in each of several females examined. The egg has been described and figured by Kaup (1871), the figure being reproduced by Chopard (1938, p. 175, fig. 151). I have removed an egg from the ovipositor of a female from New South Wales which agrees with Kaup's material. The egg is 5⅓ mm. long, oval, and slightly flattened. The chorion is much roughened and gray in color. There is an operculum bearing a convex, knoblike crown. Along one side is a raised, straplike, yellow thickening of distinctive shape.

The name *tiaratum* is taken from a Latin word meaning, "wearing a turban," in allusion to the spines at the crest of the occiput.

Material of *tiaratum* examined: ♀, near Babinda, Queensland, April, Schevill (M. C. Z.); ♀, Woodlord, Queensland, Harvard Australian Expedition, P. J. Darlington (M. C. Z.); ♀, Yungaburra, Queensland, 2,500 ft., April, P. J. Darlington (M. C. Z.); 3 ♀, 2 ♂, 4 ♂ nymphs, 1 ♀ nymph, New South Wales (8 A. N. S. P., 2 U. S. N. M.); ♀, "Australia," C. M. Hoy (U. S. N. M.).

Extatosoma popa Stål

Figures 1, 2

Extatosoma popa Stal, 1875, Rec. Orth., p. 84.
Phasma (*Extatosoma*) *tiaratum* MacL., Haan, 1842,[5] Temminck, Verhandl., Orth., p. 110, pl. 10, fig. 2. (Misidentification in part.)

Descriptive notes (female)—Very much like *tiaratum*, differing in key characters, average greater body length, and greater size development of dorsal spines. Pronotum with posterior medial spines varying from single to compound. Tegmina and wings somewhat more rudimentary than in *tiaratum*. Well-developed, paired median lamellae on mesonotum, metanotum and first to sixth terga (lacking on tergum 4, fig. 2, due to breakage). Spination of fourth, fifth and sixth abdominal sterna reduced, all except laterals lacking or poorly developed (these strongly developed in *tiaratum*).

Coloration: Preserved material brown, the head paler than the abdomen, the most striking color feature being the illustrated V-shaped mesonotal pale mark. Apical half of flexor surface of hind tibia and first four segments of hind tarsus sometimes (specimen from Sattelberg) glossy shining black. Coloration in life unknown.

Measurements (specimen from Buna) (length): Body, 125 mm.; front femur, 25 mm.; hind femur, 25 mm.; hind tibia, 32 mm.; pronotum, 11 mm.; mesonotum, 16.5 mm.; tegmen, 11.5 mm.; wing, 7.5

[5] It appears that plate 10 was published in 1840, together with pages 1–44 and plates 1–9 of the section of insects of this general zoological work.

mm.; ovipositor sheath, 22 mm. Body length of Sattelberg specimen, 110 mm.

Knowledge of this unusual insect dates from Haan (1842) who published a colored, life-size, dorsal view illustration. The V-shaped mesonotal mark and other characteristic features are so clearly shown in his figure that there is no question regarding the identity of the species. Two small lateral views of hind and middle femora were also shown. He used the name *tiaratum* for his material, but indicated a portion of it (a) as being from the coast of the middle part of eastern New Guinea, the remainder (b) from Van-Diemen Land. The latter term has been applied in past years to Tasmania as well as to parts of Northern Australia, but since *Extatosoma* is not definitely known from Tasmania, Australia was probably the source of the material and true *tiaratum* may have been included. In any event, Stal (1875), recognizing the illustrated New Guinea form of the genus as distinct from the previously known Australian *tiaratum*, proposed the new name *popa* and mentioned the differentiating characters. (The Latin word "popa" means a type of Roman priest and is sometimes used in allusion to an enlarged stomach or paunch, the association in this case evidently referring to the greatly dilated fifth, sixth and seventh terga.) Redtenbacher (1908, p. 381) treated Haan's material of categories "a" and "b" as *popa* and *tiaratum*, respectively, and gave a formal description of *popa*. He gave the body length as 152 mm., which is scarcely more than the length to the tip of ovipositor sheath of the female here recorded belonging to the Academy of Natural Sciences of Philadelphia. Crampton (1916, pp. 15, 38, pl. 2, figs. 11, 14) illustrated the lateral expansions of the terga and compared them with lateral thoracic and abdominal expansions of various other insects. Franz (1930) published a life-size photograph of a female in lateral view, under the name *tiaratum*, and without a definite locality for the specimen illustrated.

Only a few specimens have been recorded, so that no clear definition of the geographical area occupied, other than eastern New Guinea, may be made. During the past 20 years Gunther has written numerous and extensive papers on the walkingsticks of New Guinea and the Bismarck Archipelago, based primarily on collections made by German scientists prior to the first World War. It is significant that very little material of *popa* has been reported by him, and he has mentioned (1932, p. 817) the sparse occurrence of the genus in New Guinea. Material was recorded from Sattelberg (located on Huon Peninsula, about 15 miles west of Finschafen), northeast New Guinea, by Gunther (1929, pp. 612, 625) in his list of described New Guinea Phasmatidae. He discussed the altitudinal ranges of various species and placed *popa* in a middle altitudinal zone of 600–1,500 meters above sea level. Later (1937, pp. 81, 96) he attempted to group the eastern New Guinea phasmatids according to faunistic provinces, and cited *popa* as belonging to the watershed of the Sepik River and the area between Astrolabe Bay and Huon Gulf. Buna is about 150 miles southeast of Huon Gulf. Nothing is known regarding the food plants. H. C. Coe, collector of the Buna specimen here recorded, reports that it was found on the ground on dead leaves that made a background of protective coloration. No other specimens of this species were seen by him or his associates.

Material examined: ♀, Buna, northeast New Guinea, December, 1943, H. C. Coe (University of Arkansas); ♀, data uncertain, apparently eastern New Guinea, A. S. Meek (A. N. S. P.); ♀, Sattelberg, vic. Finschafen, New Guinea, March, 1933, L. Wagner (M. C. Z.).

Extatosoma elongatum Froggatt

Figure 4

Extatosoma elongatum Froggatt, 1922, Proc. Linn. Soc. N. S. Wales, vol. 47, pt. 3, p. 345, pl. 38.

This species was described as having more slender legs than *tiaratum*, with the expansions of the femora and tibiae narrow and arcuate. There are two double spines on the occipital crest of the head and erect, paired, median lamellae on the fifth and sixth terga. Slender, reddish-brown spines occur on the ventral surface of the abdomen. General color is deep green, "lightest on the wing pads"; mottling with grayish and dull white spots occurs on the abdomen and legs. Body length is 5 inches. The male is unknown.

McKeown (1940, 1944) has mentioned *elongatum* briefly; otherwise, no information other than that contained in the original description has come to my attention. Froggatt's type was from Gosford, New South Wales, where it was found on a brushy tree. It remained alive a week and laid more than 100 eggs. A second specimen before Froggatt was from Camden, New South Wales.

Genus **Cotylosoma** Wood-Mason

Cotylosoma Wood-Mason, 1878, Ann. and Mag. Nat. Hist. (5), vol. 1, p. 102. Genotype, *C. dipneusticum* W.-M., 1878. (Monotypic.)

This is a genus to which four species are now referred, these occurring in Fiji, Tonga, Tongatabu and the New Hebrides. *Cotylosoma* is noteworthy because males have not yet been discovered, as well as for the distinctive structure of the females which have been supposed to be aquatic although there was never any foundation for that belief. The species are closely related and the comparatively few specimens in collections have not permitted a thorough study of their taxonomy. *C. dipneusticum* (fig. 6) is typical, possessing leaflike lateral metathoracic appendages and ventrally concave expansions of the terga. The latter probably serve as the basis for the generic name, meaning "cuplike body." I have nothing to add to the systematic notes on the genus by Uvarov (1935).

The supposition that certain walkingsticks are aquatic originated primarily with Murray (1866) who gave a detailed account of the habits of the Brazilian *Prisopus flabelliformis* (Stoll), based on field observations made by an unknown person in South America. Wood-Mason (1878) assumed without justification that *Cotylosoma* was similarly specialized for an aquatic life. The two genera have frequently been cited in scientific works as examples of water insects, and the false basis for this conclusion was first emphasized by C. J. Gahan (1912), although the aquatic habits of *Cotylosoma* were doubted by several entomologists, including Sharp (1895, p. 273; 1898, p. 91), at an earlier date. Gahan carefully reviewed the facts regarding each genus, analyzing Murray's treatment of *Prisopus* and showing it to be valueless. Uvarov (1935)

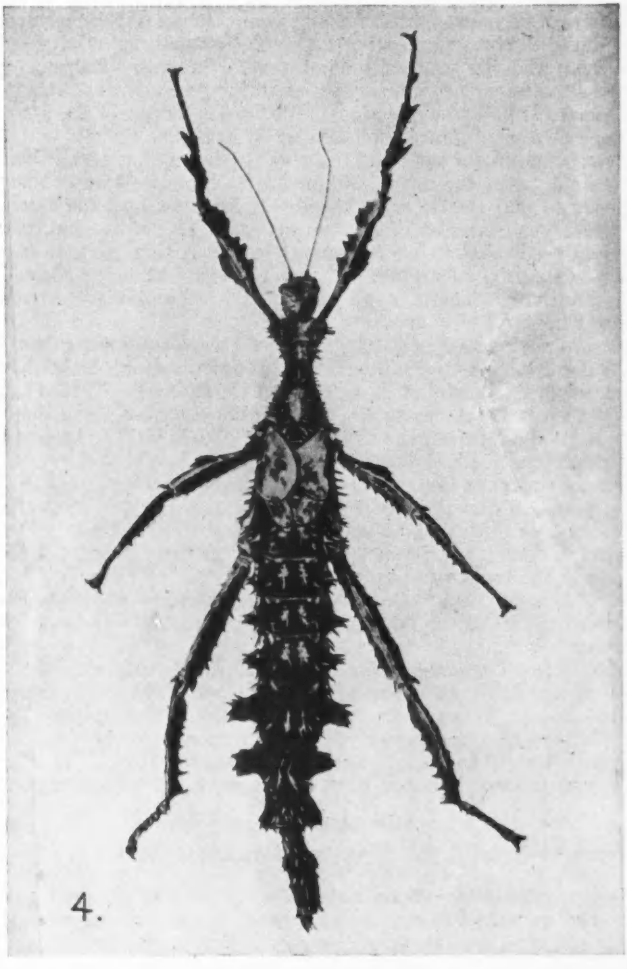


FIGURE 4. *Extatosoma elongatum* Froggatt, female, dorsal view. New South Wales. Body length, 125 mm. (After Froggatt (1922) by permission of the Linnean Society of New South Wales.)

has written an interesting and critical paper, dealing especially with *C. dipneusticum*, not only recording specimens collected far from water in the forested region of Fiji, but reporting the results of a microscopic examination of a preparation made from one of the lateral thoracic appendages. This examination failed to show any similarity between that organ and the tracheal gills of aquatic insects. The most recent authoritative review of information pertaining to aquatic Orthoptera is by Chopard (1938) who includes (p. 91, fig. 57) a copy of the drawing of the type of *dipneusticum* published by Waterhouse (1895).

As an example of the persistence of the belief that certain walking-sticks are aquatic, the recent volume on the biology of water insects by Wesenberg-Lund (1943) may be cited. *Prisopus* and *Cotylosoma* are there given as examples of aquatic insects. The native habitat of *C. dipneusticum* is said to be Borneo, the error dating back to incorrect locality data originally given by Wood-Mason but since corrected by several authors. There is no reference to the modern reviews by Gahan, Chopard or Uvarov.

An interesting test of the behavior of *C. dipneusticum* in water has been related to me by William M. Mann, director of the National Zoological Park, Washington, D. C. On December 25, 1915, Dr. Mann collected several specimens from small deciduous trees along the Navua River at Waiyanitu, on the south side of Viti Levu, the largest of the Fiji Islands. Recalling the supposed aquatic habit of the species, he placed one specimen in a pan of water, whereupon it sank to the bottom of the pan and quickly died. One of the specimens collected by Dr. Mann at Waiyanitu is recorded below. Rather than being adapted to an aquatic life, this insect is specialized so as to be camouflaged when clinging to the trunks and branches of trees, its dull brown color blending well with the bark. *C. dipneusticum* has previously been recorded only from the island of Taviuni, which is about 170 miles northeast of Kandavu.

Material of *Cotylosoma dipneusticum* W.-M. examined: ♀, Vunisea, Island of Kandavu, Fiji Islands, Wilson (U. S. N. M.). Measurements (length): Body, 92 mm.; front femur, 21 mm.; hind femur, 18 mm.; hind tibia, 16 mm.; pronotum, 6.5 mm.; mesonotum, 14 mm.; tegmen, 10.5 mm.; wing, 11 mm.; ♀, Fiji, W. M. Mann (M. C. Z.). Measurements essentially as in above specimen. Length of body, 94 mm.

Genus **Dryococelus**,[6] new genus

Karabidion Montrouzier, 1855, Ann. Soc. Agr. Lyon, (2), vol. 7, pt. 1, p. 81. (In part.)

Generic description—Body large, shining, smooth except for pleurae which are smooth, tuberculate, or weakly spined; hind femur of male greatly enlarged, heavily spined; wings lacking; front femur straight at base; abdominal segments without lateral extensions. Head prognathous; eyes large; ocelli absent; antennae simple, filiform; pronotum quadrate; mesonotum elongate-rectangular; mesopleuron tuberculate; metapleuron tuberculate (female), weakly spined (male). Dorsal

[6]Derived from three Greek words meaning "an inhabitant of hollow trees," in allusion to the frequency with which individuals of this genus have been found in the cavities of tree trunks.

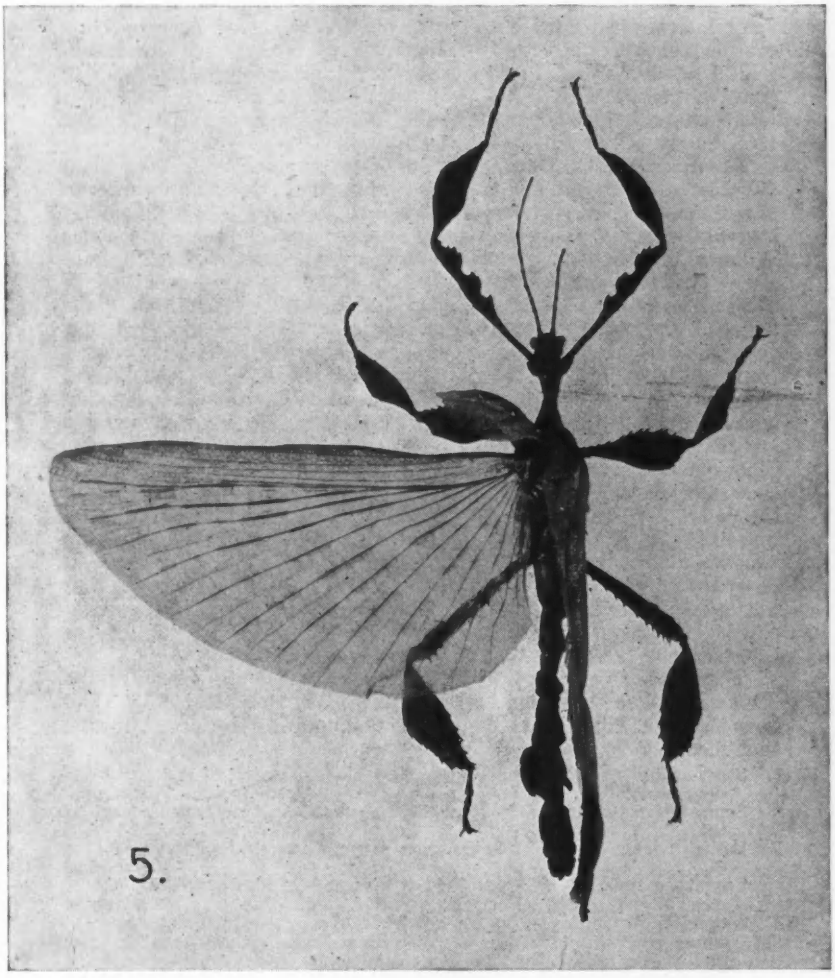


FIGURE 5. *Extatosoma tiaratum* (W. S. MacLeay), male, dorsal view. New South Wales. Body length, 83 mm.

carinae of femora (with exception of hind ones of male) feebly developed, smooth or irregular. Male hind femur with strong, basally serrate, dorsal, lateral carinae; enlarged teeth borne by ventroexternal carina; ventrolateral carinae present. Arolia moderately large. Apical tergum of male truncate or nearly so, of female short, unspecialized; female subgenital plate ventrad of apical three terga and prolonged posterior to apical tergum.

Genotype and only included species, *Karabidion australe* Montrouzier 1855, known only from Lord Howe Island.

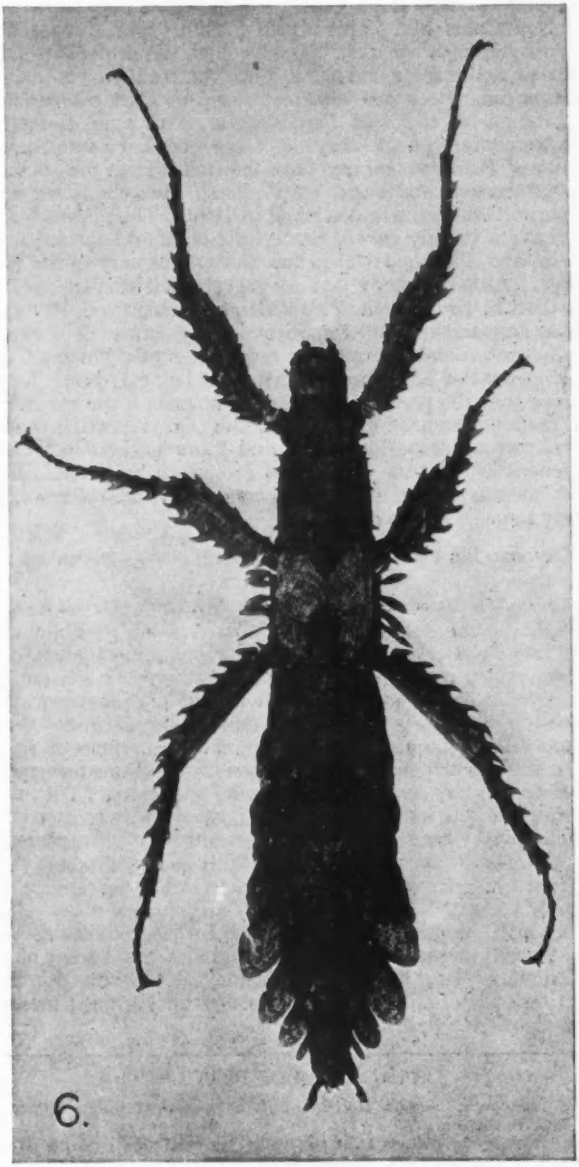
Montrouzier (1855) proposed the name *Karabidion* to replace *Eurycantha*, as being a more appropriate name for the genus. In *Karabidion* he included *Eurycantha horrida* Boisd., the only previously known member of the genus, and three new species, among which was *K. australe*. No genotype of *Karabidion* was mentioned by Montrouzier. That *Eurycantha horrida* automatically became genotype of *Karabidion* is indicated by Paragraph f, Article 30, of the International Rules of Zoological Nomenclature: "In case a generic name without originally designated type is proposed as a substitute for another generic name, with or without type, the type of either, when established, becomes *ipso facto* type of other." Consequently, the subsequent designation by Stal (1875, p. 90) of *australe* as genotype of *Karabidion* was invalid. Thus, *Karabidion* falls as a synonym of *Eurycantha*, the genotypes being identical. *Carabidion* Redtenbacher 1907 was proposed as an emendation of *Karabidion*; this is evidenced by the crediting of the name to Montrouzier and the listing of the original Montrouzier treatment of *Karabidion* in the synonymy. Though Redtenbacher included *australe* as the only species, that has no bearing on the case as he was without the power to designate any other type for a genus that was merely an emendation of one for which a genotype had been designated. A comparable situation is covered by Opinion 120 of the International Commission on Zoological Nomenclature.

The generic complex to which *Dryococelus* belongs also includes *Thaumatobactron* Gunther 1929, *Eurycantha* Boisduval 1835 and *Canachus* Stal 1875. These may be distinguished by the following simplified key:

1. Supra-anal plate and subgenital plate of female each prolonged to form an elongate ovipositor case 2
   Supra-anal plate of female not prolonged; subgenital plate prolonged or not 3
2. Vestigial tegmina present (New Caledonia, Loyalty Islands, New Hebrides), **Canachus**
   Tegmina entirely absent (New Guinea, Bismarck Archipelago, Australia, New Caledonia, Solomon Islands ..... **Eurycantha**
3. Subgenital plate of female not extending posterior to apical tergum; mesonotum twice as long as the greatest width and tapering anteriorly; hind tibia as long as hind femur; major ventral spines of hind femur of male borne along the midventral carina (New Guinea) ..... **Thaumatobactron**
   Subgenital plate of female prolonged posterior to apical tergum; mesonotum less than twice as long as greatest width and scarcely or not at all tapering anteriorly; hind tibia distinctly shorter than hind femur; major ventral spines of hind femur of male borne along ventroexternal carina (Lord Howe Island) ..... **Dryococelus**

EXPLANATION OF PLATE V

FIGURE 6. *Cotylosoma dipneusticum* Wood-Mason, female, dorsal view. Vunisea, Kandavu, Fiji Islands. Body length, 92 mm.


6.

The genus *Paracanachus* Carl 1915 was based on *Canachus circe* Redt. of New Caledonia. This is said to differ from *Canachus* in that the posterior femur of the male is less swollen, the genicular lobe is produced into an acute spine and the median ventral carina is not spinose; certain other differences were also mentioned by Carl, such as the more slender antennae in males of *Paracanachus*, with more elongate basal antennal segments. In the absence of specimens, I cannot pass upon the validity of *Paracanachus* and have omitted it from the above key.

Thaumatobactron was based on *T. poecilosoma* Gunther; a second species, *mayri* Gunther, was described in 1930. The males of *Thaumatobactron* have a basally curved posterior tibia as do certain species of *Eurycantha*, and, like the latter genus, the species vary in the spination of the legs. Although body size averages much smaller in *Thaumatobactron* than in *Eurycantha*, *T. poecilosoma* (male type, 70 mm. long) is nearly as long as the smaller species of *Eurycantha*. Most species of *Eurycantha* are around 100 mm. or more in length, however, and the type of *E. portentosa* Kirby was described as being 170 mm. long.

I believe that the presence of enlarged spines on the ventroexternal carina of the hind femur of male *Dryococelus* (fig. 12), rather than on the midventral carina, as in *Eurycantha* and *Thaumatobactron*, is a fundamental generic character. The tarsal arolium is very small in *Eurycantha*, at least as represented by *E. horrida* and *E. calcarata*, though moderately large in *Dryococelus*.

Dryococelus australis (Montrouzier), new combination

Figures 10, 11, 12

Karabidion australe Montrouzier, 1885, Ann. Soc. Agr. Lyon, (2), vol. 7, pt. 1, p. 86.

Descriptive notes (female)—Head with a shallow, oblique sulcus extending mesioposteriorly from posterior margin of each antennal socket; two punctures on dorsum mesially, slightly posterior to hind margin of eyes; antenna reaching about to middle of mesonotum. Pronotum with posteriorly convex transverse sulcus in front of middle; mesonotum and metanotum sparsely punctate; carinae of front and middle femora obsolete, of hind femur weakly developed, serrate; tarsi rounded dorsally; tarsal segment 5 subequal to segments 1–4 combined. Apical tergum short, narrowly rounded posteriorly, almost conelike in dorsal view; ovipositor sheath with about one-fourth length extending posterior to apex of last tergum, apical third gently, gradually curving dorsad, apex acute; cerci leaflike, projecting ventroposteriorly, laterad of ovipositor sheath.

Coloration: General color dark reddish brown, a blackish tinge on head and thorax; mesosternum and membranous coxal areas pale.

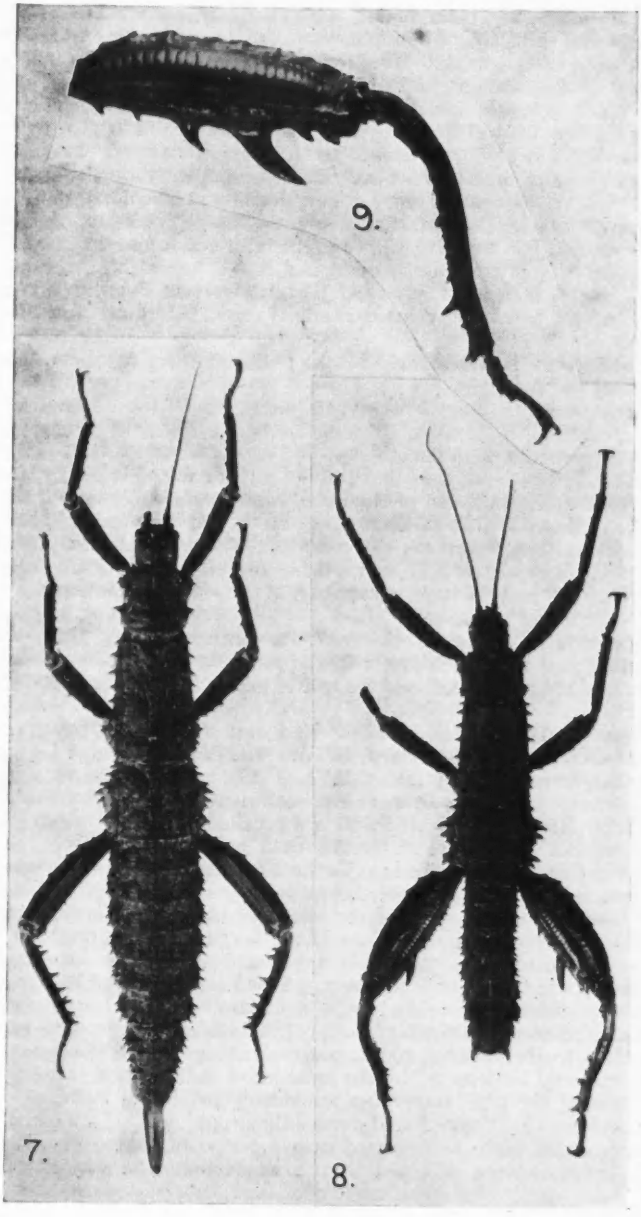
Measurements (length): Body, 120 mm.; front femur, 18 mm.; hind femur, 23 mm.; hind tibia, 18 mm.; pronotum, 12 mm.; mesonotum, 22 mm.; ovipositor sheath, 24 mm.

EXPLANATION OF PLATE VI

FIGUTE 7. *Eurycantha horrida* Boisduval, female, dorsal view. New Guinea. Body length, 150 mm.

FIGURE 8. *Eurycantha calcarata* Lucas, male, dorsal view. Milne Bay, New Guinea, March-April, 1944. Body length, 102 mm.

FIGURE 9. Same specimen as figure 8, lateral view of external surface of left hind leg.


9.
7.
8.

Male—Differing from female as follows: Tuberculation of mesopleuron and spination of metapleuron more developed; carinae of front and middle femora weak. Hind femur with dorsal, lateral carinae each bearing 6–12 serrations, mostly in basal third; internal ventral carina with about 5 teeth, increasing in size distally; about 8 small teeth along median ventral line, the largest midway of the length; external carina with 2 heavy, conspicuous teeth in apical half, the basal nearly twice as long as apical one, basal half of carina with 2 or 3 serrations. Hind tibia very arcuate, deeply sulcate dorsally in apical half; a median, irregularly notched ventral carina, bluntly toothed apically. Abdomen narrower and less tapering than in female; apical tergum nearly truncate, narrowly divided along middorsal line in apical half, the lateroapical angles somewhat extended posteriorly, broadly rounded; cerci thin, leaflike, extending ventroposteriorly; apical sternum blunt, feebly emarginate.

Coloration: Thorax nearly black; posterior margins of most body segments yellow.

Measurements (length): Body, 106 mm.; front femur, 18 mm.; hind femur, 32 mm.; front tibia, 16 mm.; hind tibia, 20 mm.; pronotum, 12 mm.; mesonotum, 21.5 mm.

Lord Howe Island, the sole locality for this unusual insect, is located about 500 miles southeast of Brisbane, New South Wales, and it should not be confused with a small island group of the same name located in the northeastern Solomons. It comprises a rocky island only 7 miles long, with a coral reef and enclosed lagoon. The flora is tropical (see Oliver, 1917), and the main occupation of the scant population has been the gathering of palm seeds.

Montrouzier's original material was obtained from "Mr. Want, Esquire," and he himself evidently did not visit Lord Howe, though he made field studies of species of the related genus *Eurycantha* at Woodlark Island.

Westwood (1859) has well described *australis*, and his figure of the male was reproduced by Sharp (1895). The distinctive hind leg of the male has been figured by Lucas (1872, pl. 10), and more accurately than in Westwood's figure. *D. australis* was briefly discussed by Etheridge (1889, pp. 31–33), who stated that it was called the "Tree Lobster" and that females were more numerous than males. Olliff (1889, p. 98) reported that almost every insect collection from Lord Howe contained specimens in all stages of growth.

Much the best account of the habits of this species is that of Lea (1916). He visited the island in December, 1915–January, 1916, and found *australis* very abundant in daytime resting places, especially in cavities in the trunks of living trees. Tree holes examined by Lea were in nearly all cases correlated with larval borings of a large longicorn beetle, *Agrianome spinicollis* MacL. Inhabited tree holes were seldom less than 18 inches long, sometimes much longer, and, if open at the bottom, could be detected by the presence of walkingstick excrement at the base of the tree, sometimes amounting to several bushels. Both eggs and egg shells were found among the droppings. It appeared that suitable holes might be occupied over a period of years. As many as 68 individuals were collected from a single hole, the majority being

immature. They apparently left the holes only at night to climb the trees and feed on leaves. Only an occasional nymph was beaten from shrubs during the day. Specimens with abnormally small legs, evidently resulting from injuries and subsequent retardation of growth or regeneration, were noted. Large spiders and cockroaches sometimes occupied the same holes with *Dryococelus*. Lea was told that when an occupied tree touched a house, the walkingsticks moved in and were noisy at night, especially in the case of thatched roofs.

Karny (1914, p. 9) and Ebner (1918, p. 234, fig. 3) have referred to this species under the name *Karabidion australe*, their notes being based on the same specimens from Yule Island (close to the New Guinea coast about 100 miles northwest of Port Moresby), but it is apparent from Ebner's illustrations that the material represented a species of *Eurycantha*.

A noteworthy chapter in the story of this remarkable insect has occurred during the last 30 years, due to the introduction of rats which have destroyed tremendous amounts of the animal life of Lord Howe. The destructive effect of the rats, especially on bird life, has been discussed by McCulloch (1921) and Hindwood (1938), but *Dryococelus* was not mentioned by those authors although Chopard (1938, p. 129) says that it is on the way to extermination by the rats.[7] Hindwood states several birds have become extinct since the rats arrived and that the introduction of the latter is usually attributed to a ship that was beached in distress in 1918. About 100 owls of several species were introduced between 1922–1930, and bounties have been paid in an effort to control the rats. It is easy to understand how *Dryococelus* would fall a prey to the inroads of rats if its habits are largely restricted to the situations described by Lea, granted of course that the rats find the insects palatable and that they spread throughout the island.

Material examined: ♂, ♀, Lord Howe Island (A. N. S. P.). Additional Lord Howe specimens at A. N. S. P. not examined.)

Genus **Eurycantha** Boisduval

Eurycantha Boisduval, 1835, Voy. Astrolabe, Ent., vol. 2, p. 647. Genotype, *E. horrida* Boisduval, 1835. (Monotypic.)
Karabidion Montrouzier, 1855, Ann. Soc. Agr. Lyon, (2), vol. 7, pt. 1, p. 81.
Carabidion Redtenbacher, 1907, Insektenfam. Phasmiden, Lief. 2, p. 340.

This is a genus of about a dozen species, occurring primarily in New Guinea and the Bismarck Archipelago. Adults are large and striking insects, varying from reddish brown to black, and usually with conspicuous spination. The accompanying illustrations (figs. 7, 8, 9) exemplify the two sexes. The generic name is derived from two Greek words meaning "large spine."

The only important literature dealing with *Eurycantha* since 1908 are the papers of Gunther (1929, 1930, 1932, 1933, 1937) in which synonymy and distribution are discussed. It should be noted that

[7]The present status of *Dryococelus* is uncertain. A note in Ward's Natural Science Bulletin (vol. 8, No. 2, p. 11, 1935) indicated that the species is extinct, but I have been informed by John W. H. Rehn, of the Academy of Natural Sciences of Philadelphia, that he has seen a recently published note suggesting that the species is maintaining itself.

Kirby (1904a) described three species, *willeyi*, *portentosa*, and *sifia*, which were omitted by Redtenbacher 4 years later.

Although specimens of *Eurycantha* are not numerous in American collections, and Montrouzier (1855) states that specimens of *E. horrida* once brought a price of 13 pounds sterling each, examples of the genus are not rare under favorable local conditions. Gunther has recorded dozens of specimens belonging to several species, though he has written little of the situations under which the material was collected. A clue to a possible method of collecting large numbers of specimens is afforded by the male of *E. calcarata* from Milne Bay recorded below, which Karl V. Krombein reports was taken during the day in a rotten stump, thereby suggesting that this species may be primarily nocturnal, spending daylight hours in shelters comparable to those occupied by *Dryococelus australis*. Bryant Rees has informed me that while on Goodenough Island, near the coast of eastern New Guinea, with American Occupation Forces in 1943, he frequently saw individuals of a large species of *Eurycantha*. A few were seen during the day crawling on the ground in clearings made for camp sites, but more were observed at night when they attracted attention by the noise of their walking over dead leaves. While no specimens were preserved, the species he encountered may well have been *Eurycantha latro* Redt., the same as discussed and illustrated by Balfour (1915). The latter described how natives of Goodenough used the hind femora of *Eurycantha* males as fish hooks. A femur was removed from the insect's body, then a string was passed lengthwise through the hollow femur and knotted outside of the trochantal opening, resulting in a sharp hook created by the major femoral tooth. Whether bait was attached to the hook was not stated. The synonymous generic name *Karabidion* is said by Montrouzier to come from "Karabok," a native name at Woodlark Island for these walking-sticks which are eaten and compared with Crustacea. It is also similar to a Greek work meaning Crustacea.

Eurycantha horrida Boisduval

Figure 7

Eurycantha horrida Boisduval, 1835, Voy. Astrolabe, Ent., 2, p. 647, pl. 10, fig. 2.

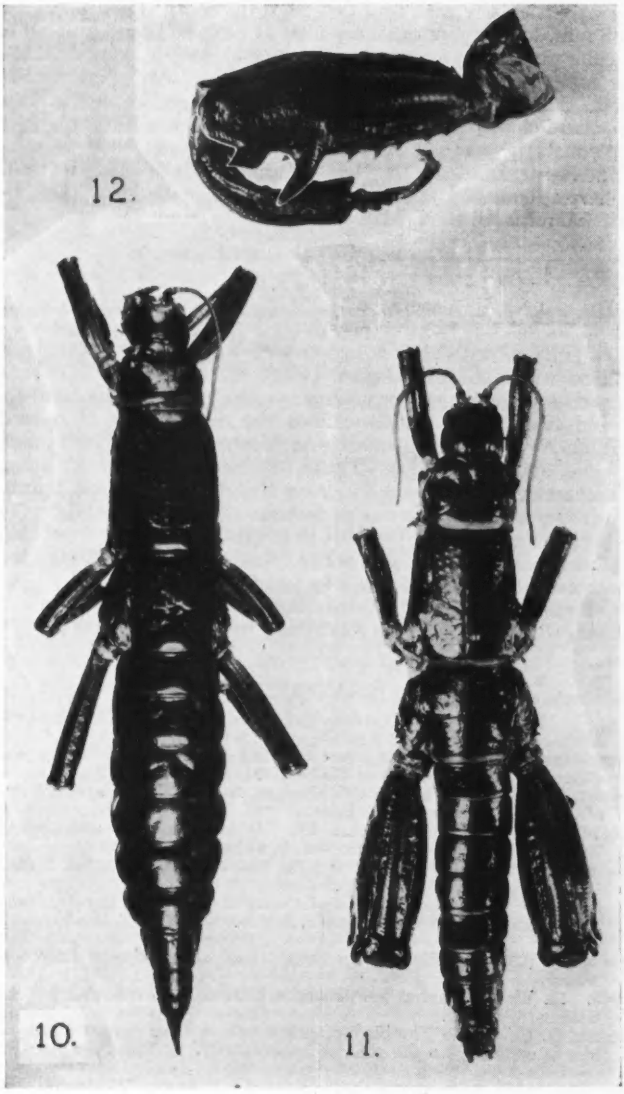
The genotype is one of several species, the males of which have large ventral spines located on the basal third of the hind tibia. Although the conspicuous femoral enlargement and tibial curvature associated with the male sex are lacking in the female, the basic arrangement of hind tibial spines is similar in both sexes. Figure 7 is from the same female specimen illustrated by Aldrich (1921, pl. 3). This species, according to Gunther (1932, p. 788), occurs in Australia, New Guinea, the Bismarck Archipelago and the Solomon Islands.

EXPLANATION OF PLATE VII

FIGURE 10. *Dryococelus australis* (Montrouzier), female, dorsal view. Lord Howe Island. Body length, 120 mm.

FIGURE 11. Same, male, dorsal view. Lord Howe Island. Body length, 106 mm.

FIGURE 12. Same specimen as in figure 11, lateral view of external surface of right hind leg.


12.
10.
11.

An egg removed from the ovipositor of one of the females recorded below agrees closely with that described by Sharp (1898, p. 85, fig. 41). It is 8 mm. long, cylindrical, rounded at each end, and grayish brown. A circular operculum forms a cap at one end, and on one side there is an ovate design, the point toward the operculum, with a crescent-shaped mark in the basal third of the design and a stemlike line at the base. The eggs of closely related species evidently do not differ markedly, as Sharp's material was not of *horrida* though so reported by him.

Material examined: ♀, "New Guinea," body length, 150 mm. (Illustrated in fig. 7.) (U. S. N. M.); ♀, "New Guinea," Dodd, body length 140 mm. (U. S. N. M.).

Eurycantha calcarata Lucas

Figures 8, 9

Eurycantha calcarata Lucas, 1870, Soc. Ent. de France Ann., (4), vol. 9, p. XXV; ibid., (5), vol. 2, p. 24, pl. 8, 1872.

The male recorded below agrees well with Lucas' original illustration, also with that of Chopard (1938, fig. 16). This species differs from *horrida* in lacking a conspicuous ventral tooth in the basal third of the hind tibia. Carl (1915) defines the distribution of *calcarata* as Australia, New Guinea, Bismarck Archipelago, the Solomons and New Caledonia, and Gunther (1933) cites its abundance in New Guinea and the Bismarck Archipelago. The New Britain material misidentified by Sharp (1898) as *E. horrida* was described as *E. willeyi* by Kirby (1904a), but Gunther (1932, p. 774) doubts that *willeyi* is distinct from *calcarata*. Sharp mentioned that a "fine series" was obtained by Willey on New Britain, and he described both eggs and nymphs.

Material examined: ♂, Milne Bay, New Guinea, in rotten stump, March-April, 1944, K. V. Krombein. Body length, 102 mm. (U. S. N. M.).

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Although the cockroach has been studied extensively the author introduces his article with the statement that little has been published on its internal anatomy. He notes also that its musculature "bears little resemblance to that of other insects."

Most of the article is composed of a list of the muscles with brief descriptions of the form, origin and insertion. A preceding section, however, which discusses the mechanism of movement, will be of considerable interest to readers who are not primarily interested in the details of anatomy.

The figures are well drawn and well reproduced and do not suffer from the translucency of paper previously noted in publications of this series.—A. W. L.

TWO NEW AMYCLE
(Homoptera: Fulgoridae)

DOROTHY J. AND JOSEF N. KNULL[1]

Amycle saxatilis Van Duzee

1914. *Trans. San Diego Soc. Nat. Hist.*, 2: 33-34.

At the request of Dr. Edward S. Ross, we hereby validate the Van Duzee selected male lectotype of this species. It is Lectotype, California Academy of Science Ent. Cat. No. 2202, locality, San Diego Co., Calif., May 21, 1913 (E. P. Van Duzee). We are indebted to Dr. Ross for sending a paratype of *A. saxatilis* for study, as well as three undetermined specimens which are included under the following descriptions.

We are grateful to Drs. John S. Caldwell and Z. P. Metcalf for information concerning this genus.

Amycle pinyonae n. sp.

Male.—Near *saxatilis* Van Duzee but larger and with the vertex distinctly shorter than combined pro- and meso-notum.

Color: Dark mottled gray, minutely irrorate anteriorly with pale, darker on middle and apex of vertex and depressed discal area of pronotum; basal half of clypeus and a spot on lateral margin of frons pale. Elytra gray, darker on disk and humeral angles, with fine pale reticulation especially prominent on apical portion; distinct white median spot on outer claval nervure, extends diffusely, obliquely on corium. Wings fumose on outer half with many transverse fuscous veinlets, longitudinal veins also fuscous. Below, abdomen and legs heavily minutely irrorate with white round spots.

Head thin and strongly produced; vertex shorter than pro- and mesonotum together, ligulate, narrowing abruptly above eyes to middle, then gradually to broadly rounded apex; surface depressed, with deep, median, linear, finely strigate groove, margined by a pair of lateral carinae which become distinct above eyes, approach one another at middle and extend about parallel to near apex; depression between these carinae and lateral carinate margins not as deep as median, lateral carinae sharp, submargin laminate carinate; a pair of oval ocellate depressions on basal disk either side nearer eyes than middle; hind margin subtruncate; post-ocular protuberance triangular, extending to middle of pronotum. Front nearly flat, a little concave; expanded sinuately to eyes from arcuate base, narrowed above antennae, broadest just above eyes, then narrowed to broadly rounded apex; disk finely striate, carinae faint except for median longitudinal carina on apical third; clypeus convex, triangular, carinate on apical half.

Pronotum transverse, one-half length of mesonotum; anterior margin bisinuate; posterior margin feebly angularly excavated; disk depressed between median and lateral raised areas, sides also depressed;

[1]Contribution from Department of Zoology and Entomology, The Ohio State University.

surface finely strigate. Mesonotum feebly tricarinate; disk and apex depressed; surface finely strigate.

Elytra almost parallel to broadly rounded apices, veins prominent, reticulation especially prominent toward apices. Hind tibiae with four lateral spines.

Female.—Base of wings red and some reddish brown irroration on base of elytra.

Length to tip of elytra: 13.8 mm.; width, 5.4 mm.

Male *holotype* and female *allotype* taken from pinyon pine (*Pinus cembroides* var. *monophylla* Voss), Pinyon Flat, Santa Rosa Mts., Calif., May 27, 1946, 4,000 ft., by D. J. and J. N. Knull, in Collection of The Ohio State University. A female *paratype* labeled Roaring Springs, Grand Canyon, Ariz., July 30, C. C. Searl collector, in collection of California Academy of Sciences.

Amycle tumacacoriae n. sp.

A greatly produced narrow head with upturned apex distinguishes this from other members of the genus, and suggests a relationship with *Scolopsella*.

Male.—Color and markings similar to those of *A. pinyonae*.

Head thin, narrow, very strongly produced; vertex distinctly longer than pro- and meso-notum together, ligulate, narrowing sinuately from base with a slight bulge on median third and again on rounded apex; surface depressed with a very narrow median groove, broader on basal third, then linear to apex, margined by sharp carinae, area between median and lateral carinae depressed, except for convexity before apex, and sharply upturned apex which arises at more than a right angle; submargin laminate, carinate; hind margin bisinuate; a pair of ocellate depressions either side near base midway between eyes and center. Front flat basally, becoming decidedly convex on apical half, with distinct median and lateral carinae; base slightly excavated; sides to above eyes sinuate, indented at ocelli, narrowed obliquely from above eyes to middle where it is about half basal width, bulging slightly, then narrowing to rounded apex; post ocular protuberance triangular; disk finely striate especially on basal half. Clypeus long, triangular, convex and with strong median carina on apical half.

Pronotum transverse, less than half length of mesonotum; anterior margin bisinuate; posterior margin broadly emarginate; depressed on anterior half, a median and strong lateral carinae; sides depressed; disk finely strigate. Mesonotum tricarinate basally, anterior submargin and lateral angles tumid; surface finely strigate; apex depressed.

EXPLANATION OF PLATE I

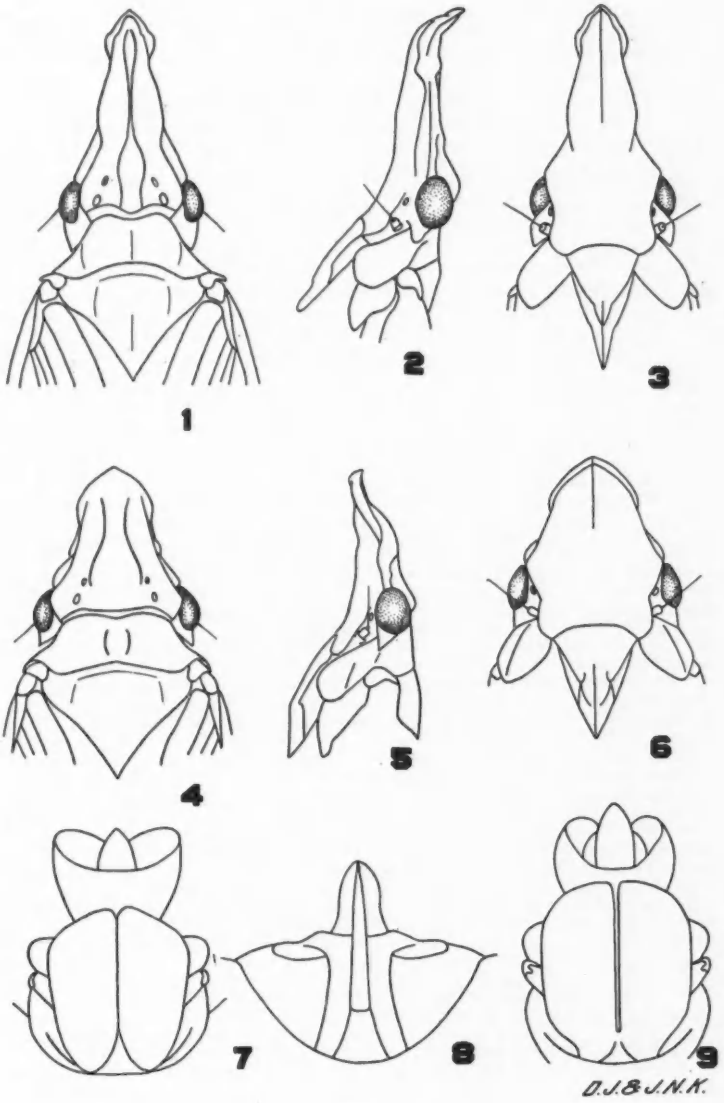
Amycle tumacacoriae n. sp.

1. Dorsal view of head.
2. Lateral view of head.
3. Front view of head.
9. Male genitalia.

Amcyle pinyonae n. sp.

4. Dorsal view of head.
5. Lateral view of head.
6. Front view of head.
7. Male genitalia.
8. Female genitalia.

All genitalia drawn under higher magnification.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D.J.& J.N.K.

Elytra narrow, sides straight, apices subangulate, flared on inner margin behind apex of clavus. Hind tibiae with four lateral spines.

Length to tip of elytra: 15.8 mm.; width, 5.7 mm.

Holotype male labeled Tumacacori Mts., Ariz., July 22, 1940, collected on dead branch of oak by D. J. and J. N. Knull, in collection of The Ohio State University. Male ***paratypes*** labeled Nogales, Ariz., October 8, 1898, Koebele, Koebele Collection, and Chisos Mts., Big Bend National Park, Tex., July 6, 1946, E. C. Van Dyke, in collection of California Academy of Sciences.

FRAGMENTS OF ENTOMOLOGICAL HISTORY, PART II, by HERBERT OSBORN. x+232 pages, 36 plates. Published by the Author, printed by the Spahr and Glenn Company, Columbus, Ohio, 1946. Price $2.75.

Doctor Osborn's *Fragments of Entomological History* is a priceless collection of material which could have come from no other pen than that of our beloved Nestor of the science. His long active life has given him an unequalled contact with entomologists and entomology during its gradual development in America and his devotion to professional interests has enabled him to share this personal knowledge in the unique *Fragments*. Few men may equal the span of his experience and of those few, still less may combine the varied qualities needed for the production of such a work.

The second volume of the *Fragments* is dedicated to Mrs. Osborn (1858–1939) and carries her photograph as a frontispiece, followed by a memorial page bearing the resolution of the Society at the time of her passing. One reads between the lines here to see the long and fine relationship which the author enjoyed in his home and to appreciate its importance in the career of an eminent scientist. As he thinks of his old and valued friend, the reviewer is forced here to revise his impulse to pay tribute to the work of Doctor Osborn and to hail instead the accomplishment of Doctor and Mrs. Osborn together.

From the Spahr and Glenn Company, the book carries a foreword of tribute to the Author.

The book includes chapters on Research Agencies, College Instruction in Entomology, Entomological Societies, International Entomological Congresses, Publications, Personal Mention, Commemorative Events and Memorials, Buildings and Equipment for Insect Study, Insecticides and Machinery, Insect Collections and Regional Notes, followed by addenda, corrections and additions for Part I and illustrations.

The material included is necessarily detailed, concise and factual. Little can be said of it in summary since it is already terse, but to reiterate that it represents a long life of personal acquaintance with the matters covered and that, as a result, it embodies a wealth of information which might, in ordinary publications, be lost to the scientific world. No entomologist can fail to find in it an immense store of helpful and interesting data—data on the resources of the science, data on progress of the past, data on the lives and experiences of other entomologists,—and with them the reassurance that comes from knowing that he does not work alone but that his problems and difficulties are such as have been experienced by others and that he too may contribute some valuable mite to the tremendous science in which he has chosen to spend his professional life.

The *Fragments* deserve a place on every entomologist's bookshelf. It will occasionally be valuable for specific reference, but more than that, it will serve to correlate the many decades of entomology as few books can. We congratulate the author on the completion of the work at an age when most men would be content to rest on accomplishments of the past and to spend their days in less productive efforts.—A. W. L.

TARSAL CHEMORECEPTORS OF THE HOUSEFLY AND THEIR POSSIBLE RELATION TO DDT TOXICITY[1]

WM. P. HAYES AND YU-SU LIU
University of Illinois

Chemoreceptive sensilla are associated with the functions of taste and smell. These are found on various parts of the body such as antennae, palpi and tarsi. Those on the tarsi are usually considered to be gustatory in function and in several species of Lepidoptera have been shown to be most sensitive to sugars. Chemoreceptive sensilla are of various types. Those associated with small, slender hairs have delicate walls and are supposed to be receptive to odors and are distinguished as chemoreceptive hairs. They fall in the category of sensilla called *sensilla trichodea*. Such hairs are innervated by a group of sense cells and not by a single bipolar sense cell as are the trichodea sensilla that are regarded as organs of touch. According to Wigglesworth (1939, p. 150), these thin-walled sensilla have no socket or trichopore at their base. The tormogen cell is often absent although the trichogen cell is usually large and secretes a product that fills the thin-walled hair. The sense cells are usually many in number and may form clusters of twenty or thirty. They are enclosed in a nucleated coat which is continuous with the neurolemma of the attached nerves. The proximal nerve being the afferent process and distal nerve forms the terminal filament.

The only histological study of tarsal chemoreceptive organs known to the writers is that of Eltringham (1933, p. 33) on the tarsal organs of the butterfly, *Vanessa* (*Pyrameis*) *atalanta* (Linn.). Since DDT is known to be a nerve poison, which has been shown by Roeder (1946) to act through the leg nerves of the cockroach, it was suggested to the writers by Prof. C. W. Kearns that a study of the peripheral nerve of the tarsus might throw some light on the mode of action of DDT. It was therefore planned to compare histologically the structures of a tarsus of an insect susceptible to DDT with some that were not susceptible to it. Accordingly, sections were made of the tarsus of the housefly, *Musca domestica* L., the German cockroach, *Blatella germanica* (L.), and the adult and larva of the Mexican bean beetle, *Epilachna varivestis* Muls. The housefly is easily killed with DDT while the German roach and the larva and adult of the Mexican bean beetle are not so susceptible to its action.

REVIEW OF LITERATURE ON CHEMORECEPTIVE SENSIBILITY OF THE INSECT TARSUS

The chemoreceptive sensibility of insect tarsi has been shown by many workers. Minnich (1921) first proved functionally the presence of chemoreceptors on tha tarsi of two nymphalid butterflies. Minnich

[1]Contribution No. 274 from the Entomological Laboratories of the University of Illinois, Urbana.

(1922 and 1929) further found in various groups of insects, especially blowflies, that it was necessary for the tarsi to come into direct contact with the material before a response was initiated. Weiss (1930) has verified the presence of contact chemoreceptors on the tarsi of the Admiral butterfly. Anderson (1930) has obtained evidence of similar receptors in the Monarch butterfly. Crow (1932) and Marshall (1934) worked on Calliphoridae and the honey-bee respectively. Both of them have confirmed the presence of chemoreceptive sensibility of the legs of those two insects. McIndoo (1934) concludes from the results of his experiments that responses of blowflies to tarsal stimulations by sucrose are of an olfactory nature rather than a gustatory nature. He further reported that only nine olfactory pores occur on the tarsi of butterflies. These olfactory pores are termed campaniform organs and are not the same structures as the chemoreceptive organs described in this paper. Campaniform organs are now thought to be proprioceptive organs. Although Verlaine (1927) disagreed with some of Minnich's results, yet Deonier and Richardson (1935) supported the latter basing their opinion upon experiments on the housefly and assumed that responses of the housefly to the sugars result from stimulation of chemoreceptive organs. After proving the presence of chemoreceptive organs on the tarsi by experimental means, Eltringham (1933) worked on the organs by histological methods and described their structure in the butterfly, *Vanessa* (*Pyrameis*) *atalanta*. This is the only histological study on insect tarsal chemoreceptors so far as the writers are aware.

MATERIALS AND METHODS

During the course of this study, three species of insects have been selected and used. The housefly, *Musca domestica* L., is known as one of the insects most susceptible to DDT, while the German cockroach, *Blattella germanica* L., and both the adult and larva of the Mexican bean beetle, *Epilachna varivestis* Muls., are recorded as less susceptible insects. In preparing the sections, legs were dissected and fixed in Bouin's fluid for twenty-four hours and then the general paraffin method was followed. Nevertheless, the chitinous exoskeleton of insects has in many cases made the general paraffin method impracticable. It has been proposed by many authors that the double imbedding or triple imbedding method be used, or to soften the sclerotized exoskeleton by chemical means, however, none of these methods is one hundred per cent satisfactory.

Since the junior writer has had more experience with the paraffin method, she did not follow the other methods in this study. But both the infiltration and imbedding periods were greatly prolonged in insuring a complete penetration of paraffin into the insect tissues through the thick sclerotized exoskeleton. Fortunately the results were found successful. Various kinds of stains have been tried, only Heidenham's iron haematoxylin, counterstained with eosin, was found satisfactory and Cajal's silver nitrate stain is good for nerve endings. Sagittal, frontal and transverse sections were made in series from six to seven microns thick. For study of the external structures, *in toto*, mounts were prepared and stained with methylene blue. Specimens of different

sexes were compared and special attention was also paid to the three different pairs of legs of the insect. No essential differences were found in the sexes or the different pairs of tarsi.

HISTOLOGY OF THE HOUSEFLY TARSUS

The tarsi (Fig. 9) are composed of five segments or tarsomeres, the first segment is the longest, the second and the fifth are subequal, and the third and fourth are the shortest. The pretarsus is located on the distal end of the fifth tarsal segment. It consists of a pair of claws and a pair of large basolateral lobes associated with the underside of the claws which are known as the pulvilli. At the bases of the claws and pulvilli two small sclerites, the planta and unguitractoral plate, are located. No muscles are to be found in the tarsi. Numerous hairs cover the surface of the tarsi.

Cuticula (Fig. 16)—The cuticula itself has a stratified appearance in sections, it contains two distinct principal layers, namely, the exocuticula (Fig. 16, EXCU), and the endocuticula (Fig. 16, ENCU). While on the exterior there is a very thin surface layer, or epicuticula (Fig. 16, EPCU) which appears in sections as a clear border line. The exocuticula is distinguishable from the endocuticula by its darker pigmentation and its denser structure. Measurements of the cuticula show it to be from 12.5 to 25 microns thick.

Hypodermis (Figs. 9 and 17, HP)—The hypodermis or epidermis is composed of ectodermal cells arranged in a single layer. However, a few exceptions are found in which the cells are arranged into two layers (Fig. 1, HP_1) or disposed irregularly (Fig. 15, HP). The shape of the cell is cubical or columnar, the latter shape has only been found on the lateroventral sides of the second tarsal segment (Fig. 17, HP) and the distal part of the first tarsal segment.

At the distal end of the fifth tarsal segment, a layer of hypodermal cells extends towards the unguitractoral tendon forming a cone-shaped structure that embraces the tendon (Figs. 1 and 24, HP_2).

Basement membrane (Fig. 1, BM)—The membrane is very thin and closely adherent to the hypodermis.

Unguitractoral tendon (Figs. 1, UT, and 11)—It is known that no intrinsic muscles exist in the tarsi. A cord-like tubular tendon extends throughout the five tarsal segments. It arises from the unguitractoral plate of the pretarsus. The so-called tendon is probably an apodeme of the unguitractoral plate. It is composed of a bundle of tendon fibrils and thin hypodermal cells externally. From a cross-section of the tendon (Fig. 13), it is observed to be a hollow tube surrounded by two distinct layers of which the central ring is thicker and darker.

Trachea (Figs. 2 and 9, TR)—Along the side of the unguitractoral tendon there is a trachea running throughout the five tarsal segments which ends in many small tracheoles near the distal hypodermis of the fifth tarsal segment. Intima and taenidia of the trachea are visible.

In a sagittal section of the first tarsal segment (Fig. 2, TG) a spindle-shaped gland is found which connects with the trachea by two thread-like prolongations of its ends. Eltringham (1932) has described a "tendon-gland" in the tarsus of *Vanessa* (*Pyrameis*) *atalanta* which is very much like that found in the housefly. The writers have carefully

traced the connections of this so-called gland and there seems to be no connection with the tendon. It seems more reasonable to call it a tracheal gland (Fig. 2, TG) although we cannot suggest its function.

Nerves (Figs. 9, NV; 10 and 12)—Two nerves run along the inside of the hypodermis throughout the five tarsal segments. One of them is associated closely with the trachea (Fig. 12, NL). A thin layer of nucleated neurolemma (NL) is distinct. The two nerves run much closer together and become coarser in the second tarsal segment than they are in the remaining segments. While in the first tarsal segment the two nerves become almost combined into a single stout nerve (Fig. 15, NV). Many small nerve branches are found at the distal part of each tarsal segment which connect with the hypodermal cells (Fig. 9).

Connective tissue (Figs. 15, 18, and 19, CN)—Connective tissue is present in spaces around the unguitractoral tendon (UT) and the nerves (NV). It is a noncellular membrane. In a cross section of the first tarsal segment the tissue seems to form a cylindrical membrane surrounding the tendon (Fig. 14, CN). In the second tarsal segment the connective tissue extends to connect with two nerves. In the third and fourth tarsal segments (Fig. 19) the cylindrical membrane has disappeared and only two short stripes of tissue (CN) connect between the tendon and the nerves. While in the fifth tarsal segment, the connective tissue is present between the nerves only and lies dorsad of the tendon (Fig. 23, CN). The layer of connective tissue apparently divides the tarsus into two distinct sinuses which are filled with blood cells and thus separates the outgoing and returning blood streams.

Sense organs—Two different types of peripheral sense organs exist in the tarsi of the housefly, namely, the tactile sensilla and chemoreceptive sensilla. No campaniform sensilla are to be found in the tarsus but they do occur in the tibia.

a. *Tactile sensilla* (Fig. 7, TTS)—These are bipolar nerve cells in an intraepidermal position. The shape of the cells is not very regular and their size is almost one and one-half times as large as other hypodermal cells. The distal process of each cell is attached to the base

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EXPLANATION OF PLATE I

Housefly, *Musca domestica* L.

Fig. 1. Frontal section of fifth tarsal segment and pretarsus. 2. Sagittal section of the proximal end of first tarsal segment, showing tracheal gland. 3. Sagittal section at the junction of the tibia and first tarsal segment, showing the tenent hairs. 4. Frontal section of pulvillus. 5. Sagittal section of the fourth tarsal segment, showing the chemoreceptive sensilla and seta. 6. Sagittal section of a spine. 7. Sagittal section of fixed hairs and tactile sensillum and its seta. 8. Cross section of a portion of the tarsal segment, showing the chemoreceptive sensilla. 9. Sagittal section of tarsus. 10. Longitudinal section of tarsal nerve. 11. Longitudinal section of unguitractoral tendon. 12. Cross section of tarsal nerve. 13. Cross section of unguitractoral tendon. 14. Cross section of first tarsal segment. 15. Cross section of second tarsal segment, showing the irregular arrangement of hypodermal cells. 16. Section of cuticula. 17. Cross section of second tarsal segment, showing the columnar hypodermal cells. 18. Cross section of second tarsal segment, showing the chemoreceptive sensilla. 19. Cross section of third tarsal segment. 20. Longitudinal section of a portion of tarsal segment, showing the chemoreceptive sensilla.

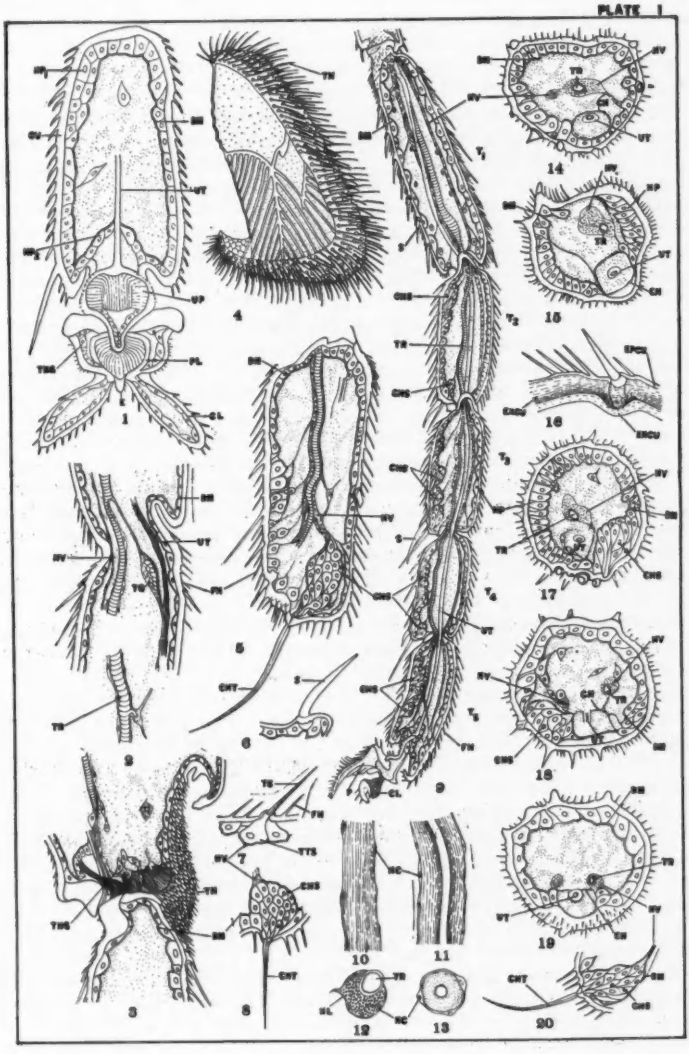
PLATE I

of a tactile seta which is long and thin-walled (Fig. 7, TS). The cell is innervated on both ends, one nerve connecting with the longitudinal tarsal nerve and the other attached to the sensory seta. The tactile sensilla are found scattered around on all sides of the tarsal segments, however, they are fewer in number on the dorsal side, but more numerous on the distal end of each segment, especially in the first tarsal segment.

b. *Chemoreceptive sensilla* (Figs. 8, 9, 20 and 22, CHS)—These are groups of sensory cells in a subepidermal position covered by a nucleated neurolemma continuous with that of the longitudinal nerve. The individual cells are more or less spindle-shaped. The distal end of the sensilla is attached to a thin-walled, long seta, known as the chemoreceptive seta (Fig. 8, CHT), and a nerve fiber can be traced from the sensilla to the center of the connecting seta. The proximal end of the sensilla is provided with a bundle of nerve fibers which connects with the longitudinal tarsal nerve (Fig. 8, NV). The chemoreceptive sensilla are located lateroventrad on the second to fifth tarsal segments. They have not been found either on the dorsal side of these segments or in the first tarsal segment. In the second tarsal segment (Fig. 9, CHS), only two chemoreceptive sensilla are found. These are located near the proximal and distal ends but not in a symmetrical position. In the third tarsal segment many chemoreceptive sensilla are found in the lateroventral area which occupy almost two-thirds of the length of the whole segment starting from the distal end. In the fourth tarsal segment, the chemoreceptive sensilla are even more numerous than those of the third tarsal segment. They occupy three-fourths of the length of the whole segment. While in the last tarsal segment, chemoreceptive sensilla are found only in the middle portion of the segment where they occupy about half the length of the segment.

Cuticular appendages—There are five different kinds of cuticular appendages on the tarsi of housefly, namely, spines, fixed hairs, tenent hairs, tactile setae and chemoreceptive setae.

a. *Spines* (Figs. 6 and 9, S)—These are stout, short, compact and curved structures scattered around on the surface of the tarsal segments. They are quite numerous on the first tarsal segment.

b. *Fixed hairs* (Figs. 7 and 9, FH)—These are the shortest appendages of the tarsal segments. They are soft, fine and numerous.

c. *Tenent hairs* (Figs. 3, 4, and 25, TH)—The tenent hairs on the pulvilli are long and slender hairs with movable bases which lead to the fine channels inside (Fig. 4). What appear to be tenent hairs are found on the junction of the tibia and first tarsal segment (Fig. 3, TH). They are very short with large bases and are provided with fine channels inside. The writers are unaware of these structures ever having been noted before.

d. *Tactile setae* (Fig. 7, TS)—These are long, fine, thin-walled setae provided with an articulating joint at the base. Each tactile seta is connected with a bipolar tactile sensillum (Fig. 7, TTS).

e. *Chemoreceptive setae* (Figs. 5, 8, and 9, CHT)—These setae connect with the chemoreceptive sensilla. When compared with the tactile seta, the former are much longer and comparatively more slender. At the base of the seta is a distinct joint. The wall of the seta is thin. Inside of it is a visible nerve fiber connected with the chemoreceptive sensilla.

Pretarsus (Fig. 25, PT)—At the distal end of the fifth tarsal segment is the pretarsus which is composed of an unguitractoral plate (Fig. 1, UP), a sclerotized planta (Fig. 1, PL), a pair of claws (Fig. 1, CL), a pair of pulvilli (Fig. 1, P), and a short empodium (Fig. 1, E).

a. *Unguitractoral plate* (Fig. 1, UP)—The unguitractoral plate is divided into two sclerites, the distal one is distinguished as the planta (Fig. 1, PL). These are two heavily sclerotized, striated plates. Hypodermal cells are present in each distal end (Fig. 25). The cells in the planta are large and connected with the channels of the pulvilli. They are believed to be the tenent gland cells (Fig. 1, TNG).

b. *Claw* (Fig. 1, CL)—The claw is a hollow structure containing a layer of hypodermal cells. On the outside of the claw, there are many short, fine spines.

c. *Pulvillus* (Fig. 4)—The pulvillus is a hollow membranous structure with numerous internal channels. On the surface of the membrane there are numerous fine tenent hairs (Fig. 4, TH).

d. *Empodium* (Fig. 1, E)—The empodium is a small swollen sclerotized portion on the distal end of the pretarsus between the pulvilli. The structure is hollow inside and no cells are found in it.

HISTOLOGY OF THE ADULT MEXICAN BEAN BEETLE TARSUS

The tarsi (Fig. 27) are four-segmented, the fourth segment is the longest, the first shorter than the fourth, but stouter, the third is the shortest, while the second is an oblique elongate segment which is strongly developed transversely in the distoventral direction. The surface of the tarsus is covered with numerous fine hairs. However, it is characteristic that the venters of the first and second segments have rows of long and fine tenent hairs (Figs. 27, 30 and 31, TH), which do not appear on the dorsal surface and the remaining segments. The distal end of the tarsus bears the pretarsus which includes an unguitractoral plate and a pair of claws.

Cuticula (Figs. 26 and 27, CU)—The epicuticula (Fig. 26, EPCU) is a yellowish border line, while the exocuticula (Fig. 26, EXCU) and the endocuticula (Fig. 26, ENCU) are two thicker layers. The former can be distinguished by the darker and denser structure. The measurements of the cuticula are from 25 to 45 microns thick.

Hypodermis (Figs. 31, HP)—The hypodermis is a single layer of cubical cells. It is quite uniform in appearance throughout all of the four segments. Nevertheless, on the venter of the first and second segments columnar cells are found. The columnar cells are glandular cells which are larger in size and each is located at the base of a tenent hair (Fig. 30, TH).

Basement membrane (Figs. 27 and 28, BM)—The membrane is very thin and adheres closely to the hypodermis.

Unguitractoral tendon (Figs. 27, UT and 29)—A long, tubular tendon runs throughout the four tarsal segments. It starts at the unguitractoral plate of the pretarsus. In a cross section of the tendon, it is seen to be a hollow tube. (Fig. 32, UT.)

Trachea (Fig. 27, TR)—Along the dorsal side of the unguitractoral tendon there is a large trachea running throughout the four tarsal segments. Intima and taenidum are very distinct.

Nerves (Fig. 27, NV)—A pair of nerves is present. The dorsal one runs along the side of the hypodermis and another is associated with the trachea. They become closer and closer to each other at the proximal part of the tarsus. Nerve fibers are found connected with the hypodermal cells at the distal end of the tarsus.

Connective tissue (Fig. 31, CN)—The spaces between the nerves and trachea are connected with loose connective tissue which separates the blood stream. Many large oenocytes are found in the blood.

Sense organs (Fig. 28, TTS)—Tactile sensilla are found only on the distal end of the third and fourth tarsal segments. They are scattered. Each is connected to a long, tactile seta. No chemoreceptive sense cells are present.

Cuticular appendages—There are three different types of cuticular appendages located on the tarsal surface, namely, fixed hairs, tenent hairs and tactile setae. These may be distinguished as follows:

a. *Fixed hairs* (Figs. 26 and 33, FH)—Fixed hairs are the short hairs which are scattered over the surface of all the tarsal segments.

b. *Tenent hairs* (Figs. 27 and 30, TH)—These long curved hairs are found only on the ventral surface of the first and second tarsal segments and are arranged into rows. They are long and slender with a follicle-like structure at the base which is imbedded in the cuticula. Each tenent hair is connected inside with a tenent gland cell (Figs. 27 and 30, TNG).

c. *Tactile setae* (Fig. 28, TS)—A number of tactile setae are scattered over the venter of the distal end of the third and fourth tarsal segments, each is connected with a tactile sensillum by a fine nerve fiber.

Pretarsus—An unguitractoral plate (Fig. 27, UP) is located at the distal end of the fourth tarsal segment. On the venter of the unguitractoral plate are numerous fine, short, scale-like structures. In the cavity within the unguitractoral plate, loose and irregular hypodermal cells are found. A pair of hollow claws is situated distad of the unguitractoral plate (Fig. 27, CL). A layer of elongate hypodermal cells is found within the claws.

EXPLANATION OF PLATE II

Housefly, *Musca domestica* L.

Fig. 21. Cross section of third tarsal segment, showing the chemoreceptive sensilla. 22. Cross section of fourth tarsal segment, showing the chemoreceptive sensilla. 23. Cross section of the proximal end of fifth tarsal segment. 24. Cross section of the distal end of fifth tarsal segment. 25. Longitudinal section of pretarsus.

Mexican bean beetle adult, *Epilachna varivestis* Muls.

Fig. 26. Section of cuticula. 27. Sagittal section of tarsus. 28. Longitudinal section of a portion of tarsus showing the tactile sensillum and seta. 29. Longitudinal section of unguitractoral tendon. 30. Tenent glands and hairs. 31. Cross section of first tarsal segment. 32. Cross section of fourth tarsal segment. 33. Cross section at the junction of the distal end of the fourth tarsal segment and pretarsus.

Mexican bean beetle larva, *Epilachna varivestis* Muls.

Fig. 34. Sagittal section of tibiotarsus. 35. Cross section of the proximal end of the tibiotarsus. 36. Sagittal section of pretarsus. 37. Longitudinal section of the distal end of the tibiotarsus. 38. Cross section of the distal end of the tibiotarsus. 39. Longitudinal section of trachea.

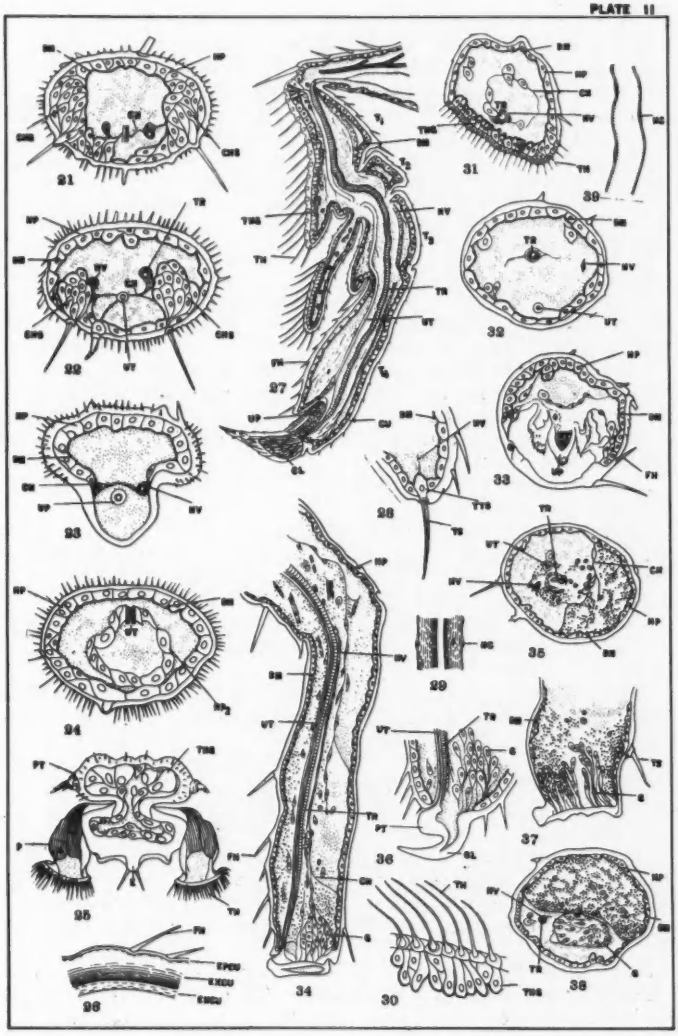
PLATE II

HISTOLOGY OF THE MEXICAN BEAN BEETLE LARVAL TIBIOTARSUS

The tarsus of the Mexican bean beetle larva is fused with its tibia and known as a tibiotarsus. On the distal end of the tibiotarsus is a pretarsus which includes a very short well-sclerotized segment and a single claw. Covering the surface of the tibiotarsus are many long and short setae which occur more abundantly on the ventral side.

Cuticula (Fig. 43)—The epicuticula (EPCU), exocuticula (EXCU), and endocuticula (ENCU) are easily distinguishable in the sections. On the surface of the cuticula there are many setae. The measurements of the cuticula are from 15 to 40 microns thick.

In one preparation, two distinct layers of cuticula are seen; it is quite possible that the insect was in an ecdysis stage and the exterior layer is the old cuticula (Fig. 42, CU_1) while the interior one is the new cuticula (Fig. 42, CU_2).

Hypodermis (Fig. 34, HP)—A single layer of cubical epithelial cells is seen in the longitudinal section; however, they appear as squamous cells from the surface view (Fig. 41). In one preparation in which the insect probably was in an ecdysis stage, the hypodermal cells are quite loose, not arranged into a continuous layer, but irregularly and separately situated from each other underneath the cuticula. Among these loosely arranged hypodermal cells, the space is filled with numerous blood cells.

Basement membrane (Fig. 34, BM)—The basement membrane is very distinct in the preparations.

Unguitractoral tendon (Figs. 34 and 45, UT)—A hollow tendon arises from the base of the pretarsus and extends throughout the tibiotarsus. In a cross section of the tendon, a darker ring is visible near the center (Fig. 44).

Trachea (Figs. 34 and 39)—There is a trachea running throughout the tibiotarsus and ending at the unguitractoral plate. Intima and taenidia are visible.

Nerves (Figs. 34, 35 and 38, NV)—A pair of very fine nerves runs along the hypodermis throughout the tibiotarsus. Many nerve fibers communicate with the hypodermal cells.

Connective tissue (Fig. 35, CN)—The connective tissue is a noncellular membrane dividing the tarsus dorsoventrally. On the dorsal side of the membrane, the size of the blood cells is evidently much larger than those of the ventral side.

Sense organs—Only a few tactile sensilla (Fig. 40, TTS) are found. The hypodermal sense cells are connected with external tactile setae (Fig. 40, TS) by fine nerve fibers. This kind of hypodermal sense cell is spindle-shaped and comparatively larger than the ordinary hypodermal cells.

Gland (Figs. 34, 36 and 37, G)—A group of elongate cells is found at the dorsodistal end of the tibiotarsus. They are believed to be gland cells because of their appearance, but their function is unknown.

Cuticular appendages—There are two different types of cuticular appendages on the tibiotarsus. One is the tactile seta (Fig. 40, TS) which is thin-walled with a joint at base and longer than the other type. The tactile setae are found mostly on the distal end of the segment. Another is the fixed hair (Figs. 34, 42, and 43, FH) which is

shorter than the tactile seta. The fixed hairs are found more abundantly on the ventral side of the segment.

Pretarsus (Fig. 36, PT)—At the distal end of the tibiotarsus there is a well-sclerotized oval plate connected with a single claw (Fig. 36, CL). The claw is very stout and strongly curved.

HISTOLOGY OF THE GERMAN COCKROACH TARSUS

The tarsi of the German cockroach (Fig. 51) are composed of five segments; the first segment is the longest, the fifth is shorter than the first, the second is again shorter than the fifth, while the third and fourth are subequal and much shorter than the rest. The surface of the tarsal segments is covered with many spines and hairs. The pretarsus consists of an unguitractoral plate, a pulvillus, and a pair of large claws.

Cuticula (Fig. 47)—The epicuticula (EPCU), exocuticula (EXCU) and endocuticula (ENCU) are very distinct. The epicuticula is thin and yellowish in color. The exocuticula is thicker and darker than the endocuticula. The measurements of the cuticula are from 60 to 90 microns thick.

Hypodermis (Fig. 56, HP)—The hypodermal cells are arranged in a single layer and quite uniformly cubical-shaped. However, a layer of spindle-shaped cells (Fig. 46, HP) is found at the ventrodistal end of all the tarsal segments which is provided with distinct connective fibers that connect with the unguitractoral tendon. Since there is neither an external opening nor setal appendage on the cuticula connected with these cells, they are hardly believed to be sense cells. At the distal end of the fifth tarsal segment, a layer of hypodermal cells runs toward the unguitractoral tendon forming a cone-shaped structure that embraces the tendon (Figs. 48 and 62, HP_2).

Basement membrane (Figs. 48 and 56, BM)—The basement membrane is very distinct and closely adherent to the hypodermis. It is thin and bright in the preparations.

Connective tissue (Figs. 57, 61, and 62, CN)—In a cross section of the tarsal segment, the connective tissue is seen to run transversely from each side of the segment to form a septum which divides the segment into two hemispherical chambers. In the dorsal chamber, the tarsal nerves and the trachea are located, while in the ventral chamber, only the unguitractoral tendon is present. The size of the blood cells is distinctly larger in the dorsal chamber.

Unguitractoral tendon (Figs. 51 and 56–61, UT)—A tendon arises from the unguitractoral plate and extends throughout the five tarsal segments. The structure of this tendon is curious. It is a hollow tube surrounded by a layer of large cells each with a remarkable nucleus. In the first tarsal segment the cells are present on all sides of the tendon (Figs. 52, 53, 56, and 57, UT), while in the remaining tarsal segments, the supporting cells are present only on one-half of the surface of the tendon, leaving the other half naked. The supporting cells are present either on the dorsal side or on the ventral side and this condition seems to alternate in the tarsal segments from the second to the fifth. In other words, in the second segment, the supporting cells are present on the ventral side of tendon (Fig. 58, UT), in the third segment, they are

present on the dorsal side (Figs. 54 and 59, UT), in the fourth segment they are present on the ventral side and in the fifth segment they are present on the dorsal side again (Figs. 55 and 61, UT).

Trachea (Figs. 51 and 56, TR)—A main trachea runs throughout the five tarsal segments with three branches in the first tarsal segment (Fig. 57, TR). The trachea and also its branches lie in or near the septum of connective tissue (Fig. 61, TR). Intima and taenidia are distinct.

Two tracheal glands similar to that found in the housefly are found in the first tarsal segment; each is connected with the tracheal wall. They are located near the proximal end and the distal end of the segment (Fig. 51, TG).

Nerves (Figs. 49, 50, and 51, NV)—A pair of nerves run along the side of the hypodermis throughout the five tarsal segments. One of them is associated closely with the trachea. A thin layer of nucleated neurolemma is distinct (Fig. 50, NL).

Sense organs—Pringle (1938) found campaniform sensilla present on the tarsus of American cockroach. These he believes respond to strains in the cuticle and react to contact pressure in the tarsus. In the German cockroach there has not been found either the campaniform sensilla, the chemoreceptive sensilla, or even the tactile sensilla.

Cuticular appendages—Two types of appendages are present on the cuticula; one is the large stout spine and another is the seta. The spines are mostly present on the distal end of each segment (Figs. 46 and 51, S), while the setae are located over the entire surface of each segment (Figs. 46, 47, and 56, ST).

Pretarsus—The pretarsus consists of an unguitractoral plate, a single pulvillus, and a pair of claws.

a. *Unguitractoral plate* (Fig. 51, UP)—The unguitractoral plate is located on the distal end of the fifth tarsal segment. It has very fine ridges on the ventral side. The internal cavity of the plate is fully filled with cells.

EXPLANATION OF PLATE III

Fig. 40. Section of tactile sensilla and setae. 41. Surface view of hypodermal cells. 42. Section showing layers of cuticula during the molting stage. 43. Section of cuticula not in molting stage. 44. Cross section of unguitractoral tendon. 45. Longitudinal section of unguitractoral tendon.

German cockroach, *Blatella germanica* L.

Fig. 46. Longitudinal section of the distal end of the fourth tarsal segment. 47. Section of cuticula. 48. Frontal section of the fifth tarsal segment and pretarsus. 49. Longitudinal section of tarsal nerve. 50. Cross section of tarsal nerve. 51. Sagittal section of the entire tarsus. 52. Longitudinal section of unguitractoral tendon in first tarsal segment. 53. Cross section of unguitractoral tendon in the first tarsal segment. 54. Longitudinal section of the unguitractoral tendon in the third tarsal segment. 55. Cross section of the unguitractoral tendon in the fifth tarsal segment. 56. Longitudinal section of first tarsal segment. 57. Cross section of first tarsal segment. 58. Cross section of second tarsal segment. 59. Cross section of the third tarsal segment. 60. Cross section of the fourth tarsal segment. 61. Cross section of the fifth tarsal segment showing the trachea lying in the connective tissue. 62. Cross section of the distal portion of the fifth tarsal segment. 63. Cross section of the distal end of the fifth tarsal segment, including a part of the pretarsus.

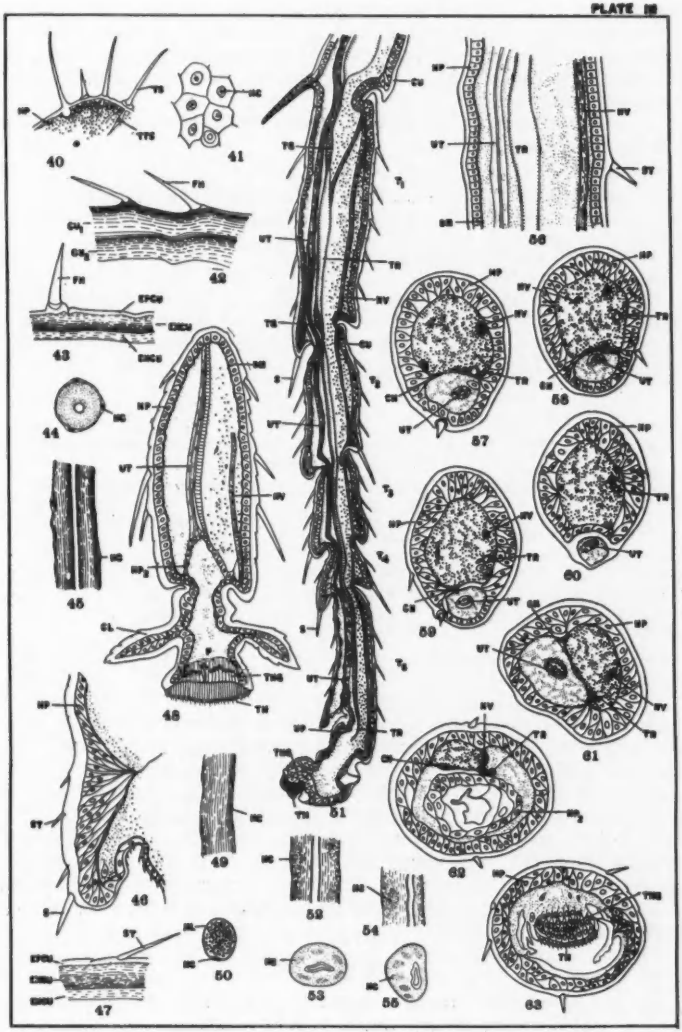
PLATE III
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b. *Pulvillus* (Fig. 48, P)—The pulvillus is a bell-shaped membranous structure with numerous tenent hairs on its surface (Figs. 48, 51, and 63, TH). The distal end of the pulvillus is invaginated and forms two folds at the tip. A layer of gland cells comprising the tenent gland (Fig. 48, TNG) is present at the distal margin and a layer of hypodermal cells runs along the lateral margins. Nerve cells are present in the cavity.

c. *Claws* (Fig. 48, CL)—The claws are hollow structures containing a layer of hypodermal cells.

DISCUSSION OF THE HISTOLOGICAL DIFFERENCES AMONG THOSE INSECTS STUDIED IN RELATION TO THE RESPONSES OF DDT

In comparing the histological structures of the tarsi of those insects that have been studied, two aspects are deemed important in relation to the responses of these insects to DDT. One is the thickness of the exoskeleton and another is the presence or absence of the chemoreceptive organs in the tarsi. For analyzing these two factors, a tabulation (Table I) is given to show their interrelations.

TABLE I

A COMPARISON OF THE THICKNESS OF THE EXOSKELETON, CHEMORECEPTIVE ORGANS AND MORTALITY

Species	Thickness of Exoskeleton	Chemoreceptive Organ	Mortality to DDT
Housefly.....	12.5–25 microns	present	high
Mexican bean beetle.....	25–45 microns	absent	low
Mexican bean beetle larva	15–40 microns	absent	low
German cockroach.....	60–90 microns	absent	low

There is no attempt to conclude here that the responses of these insects to DDT are merely because of the presence or absence of chemoreceptive organs or the thickness of the exoskeleton of the tarsi. However, the housefly which has the chemoreceptive organs in the tarsi, is more susceptible to DDT, and on the other hand, those insects such as the German cockroach and the Mexican bean beetle, both adult and larva, which have no chemoreceptive organs in the tarsi, are less susceptible to DDT. In order to conclude that the chemoreceptive organs and the thickness of the exoskeleton are the two most important factors in relation to the responses to DDT, a lot of experimental work is needed.

SUMMARY

1. An histological study was made of the tarsi of three species of insects which included the adult housefly, *Musca domestica* L., the adult German cockroach, *Blattella germanica* L., and both the adult and larva of the Mexican bean beetle, *Epilachna varivestis* Huls.

2. The histology of the tarsi of three different species of insects was studied in detail. The main structures are the cuticula, hypodermis

and basement membrane which form the wall, while the trachea, an unguitractoral tendon and a pair of nerves occur within and run throughout the tarsal segments. On the cuticula there are several kinds of appendages, such as the spines, fixed hairs, tactile setae, tenent hairs and chemoreceptive setae.

3. Among the three species studied, the chemoreceptive sensilla were found only in the tarsi of the housefly. They are located latero-ventrad on the second to fifth tarsal segments and have not been found either on the dorsal side of those segments or in the first tarsal segment. The chemoreceptive organ is composed of a group of sense cells located in a subepidermal position and covered by a nucleated neurolemma continuous with that of the longitudinal nerve. The individual cells are more or less spindle-shaped. The distal end of the sensilla is attached to a long, thin-walled chemoreceptive seta.

4. The thickness of the cuticula has been measured; that of the housefly is 12.5 to 25 microns, the Mexican bean beetle is 25 to 45 microns, the Mexican bean beetle larva is 15 to 40 microns, and the German cockroach is 60 to 90 microns. In general, it may be said that the DDT susceptible housefly has a thinner cuticula than the other non-susceptible species.

ABBREVIATIONS

BM.....Basement membrane.
CHS.....Chemoreceptive sensilla.
CHT....Chemoreceptive seta.
CL.....Claw.
CN.....Connective tissue.
CU.....Cuticula.
CU_1.....Old cuticula.
CU_2.....New cuticula.
E.....Empodium.
ENCU...Endocuticula.
EPCU...Epicuticula.
EXCU...Exocuticula.
FH.....Fixed hair.
G.....Gland.
HP.....Hypodermis.
HP_1.....Two layers of hypodermal cells.
HP_2.....Hypodermal cells invaginated into the distal end of the fifth tarsal segment.
NC.....Nucleus.
NL.....Neurolemma.
NV.....Nerve.
P.....Pulvillus.
PL.....Planta.
PT.....Pretarsus.
S.....Spine.
ST.....Seta.
T.....Tarsus.
T_1.....First tarsal segment.
T_2.....Second tarsal segment.
T_3.....Third tarsal segment.
T_4.....Fourth tarsal segment.
T_5.....Fifth tarsal segment.
TG.....Tracheal gland.
TNG....Tenent gland.
TH.....Tenent hair.
TR.....Trachea.
TS.....Tactile seta.
TTS.....Tactile sensillum.
UP.....Unguitractoral plate.
UT.....Unguitractoral tendon.

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AN INSECT BOOK FOR THE POCKET, by EDMUND SANDARS. 349 pages, 36 colored plates, numerous text figures. Geoffrey Cumberlege, Oxford University Press, London, 1946.

As might be supposed, this small volume deals especially with insects of the British Isles and is a general treatment which contributes far more to the development of broad knowledge of insects and other Arthropoda than to acquaintance with the many species. It should be exceedingly valuable to the nature lover who seeks to know this vast division of the animal kingdom but is content to recognize bees and wasps and other forms and to know something of their lives without being concerned with the identification of species.

The amount of information included is astonishing in so small a book, but the 400-word pages, attained by the limitation of margins with no loss of legibility, and the reduction of type size in the routine treatment of morphological data and life cycles still further contributes to the making of a volume of considerable actual size within dimensions small enough for the pocket.

The text is very well written. It is somewhat surprising to find ordinary words such as foot and toe mingled with the special terms of entomology, but the author is meticulous in making his meaning clear and he attains a fresh and readable style by his method. He has met the difficult task of presenting an exceedingly complex group to the uninformed with admirable success. Indeed, when one considers that this is a Comstock or an Imms or even a Schröder boiled down to a companion on rambles afield, the result is quite astonishing.

The book concludes with a brief bibliography and an index. Unfortunately the price has been clipped from the jacket of the review copy and therefore cannot be quoted, for, in spite of emphasis on the British fauna, the book should be both interesting and informative to beginners in entomology, either young or old, wherever they may live.—A. W. L.

A SEROLOGICAL STUDY OF SOME ORTHOPTERA

CHARLES A. LEONE
Department of Zoology, Rutgers University,
New Brunswick, New Jersey

Many different classifications have been devised relating insects, chiefly on the basis of their morphology. In their broader outlines these classifications show general agreement. When the systematic relations of orders to each other, and the relations of different genera within an order are in question, almost as many arrangements can be found as there are authors on the subject. Whenever there is an uncertainty in the relations of these groups, a classification showng these of necessity express the views of the individual who devised it. Some taxonomists (Blatchley 1920) have expressed the opinion that one order could follow another in almost any sequence without serious loss to the expression of their systematic relationships. Fernald (1921), however, cited the need for a reliable, objective method in determining insect relationships.

Granted that the antigenic constitution of organisms is a part of their essential nature, then the technique of precipitin testing should make it possible to conduct an objective, and quantitative analysis of the systematic relationships of insects or any other kinds of organims. The interfacial or ring test as described by Boyden (1926) has proven itself to be of considerable value in serological studies. An improvement in technique has been made by the use of photoelectric measurements of the turbidities developed in precipitin reactions. The Libby photronreflectometer (1938) appears to be an instrument by which species, and sometimes types within a species, might easily and consistently be distinguished, (Boyden and DeFalco 1943).

Serological methods present a new basis for systematic studies by concerning themselves with the analysis of similarities and dissimilarities in the antigenic constitution of different organisms. Biochemical investigations of the serologically active chemical constituents of the body may be the most objective methods possible for dealing with the essential natures of these organisms.

Erhardt (1929) presents a review of early investigations conducted on the serological classification of insects. Experiments by Brown and Heffron (1928), Martin and Cotner (1934), and Cumley (1940) have shown high correlation between the precipitin reactions of extracts of insect bodies and their present systematic positions.

This paper extends the studies in the systematic serology of insects and deals principally with the family Blattidae (Roaches) of the order Orthoptera. Certain other insects in the same order are used also to introduce interfamily relationships. An attempt is made to consider some of the principal objections to the use of this biochemical method in systematic studies.

MATERIALS AND METHODS

Antigen extracts were prepared from each of the species listed below. Identifications of the forms used were checked against Blatchley (1920).

Order ORTHOPTERA

	Common Name	Scientific Name	Key
1.	American roach	*Periplaneta americana* (Linn.)	CA and CAA
2.	Surinam roach	*Pycnoscelus surinamensis* (Linn.)	CAu
3.	German roach or Croton Bug	*Blatella germanica* (Linn.)	CG and CGG
4.	Oriental roach	*Blatta orientalis* Linn	CO
5.	Tropical roach	*Leucophaea maderae* Fabr	CL
6.	Broad Wood-roach	*Parcoblatta lata* (Brunn)	CBb
7.	Florida lubber grasshopper	*Romalea micropiera* (Beauv.)	GLu
8.	Red-legged grasshopper	*Melanoplus femur-rubrum* (DeG.)	GRl
9.	Straight-lanced grasshopper	*Conocephalus strictus* (Scudd.)	S2
10.	Chinese mantis	*Paratenodera sinensis* (Sauss.)	PM
11.	Common field cricket	*Gryllus assimilis*	KC

Insects used in the tests were gathered in the field or secured from sources recommended by the Rutgers University Department of Entomology.

PREPARATION OF ANTIGENS

All the antigens used in these experiments were prepared directly from fresh material. The insects were gathered in the field, or secured from other sources, brought into the laboratory and starved for forty-eight hours. This was done to help in the removal of any soluble proteins from the digestive tracts which might later influence some of the cross reactions.

In preparation of the saline extraction, the wings were removed as were the tibia and tarsi of the legs, just before grinding, since these parts are composed chiefly of chitin and would only interfere in the grinding operation. When only a small number of individuals was available the insects were ground in sand with mortar and pestle. When large numbers of organisms were used, as was the case with the roaches, the entire insect collection was first macerated and crushed with an ordinary hand-operated meat grinder and then ground with mortar and pestle. During both types of preparations 0.85 per cent buffered saline (ph 7) was added to prevent the drying and denaturation of soluble fractions. No attempt was made to add a constant amount of saline per unit weight of organisms since the extracts were later standardized in terms of protein nitrogen (Table I). When only a small number of organisms was available, a relatively larger amount of saline had to be added in order to provide volumes of extracts large enough to conduct the projected experiments.

The saline-insect mixtures were shaken steadily by machine for fifteen minutes and then placed in the refrigerator at $3 \pm 1^{\circ}$ C. for twenty-four hours. At this time the extraction mass was shaken again for five minutes and returned to the cold chamber. Approximately twenty-

four hours later the extraction mass was clarified by the following processes:

(1) Pressed through fine bolting cloth to remove chitinous and other heavy particles.

(2) Centrifuged for one hour at 2500 r.p.m.

(3) The milky supernatant liquid was decanted off and centrifuged again for one hour at the same speed.

(4) The supernatant liquid then was given a nonsterile preliminary filtration through a Seitz filter, changing pads as often as necessary.

(5) A final sterile filtration through the Seitz filter was performed. The sterile extract was bottled in serum vilas and stored in the refrigerator until used. In no case was a preservative used with these antigen solutions.

TABLE I

PROTEIN NITROGEN IN EXTRACTS OF VARIOUS ORTHOPTERA

Organism	Key	Protein in Grams/10 cc.
1. American roach	CA1	0.82
2. American roach	CAA1	0.70
3. Surinan roach	CAu1	0.09
4. German roach	CG1	0.77
5. German roach	CGG1	0.52
6. Oriental roach	CO1	0.92
7. Tropical roach	CL1	0.69
8. Broad Wood-roach	CBb1	0.06
9. Florida lubber grasshopper	GLu	0.08
10. Red-legged grasshopper	GR11	0.32
11. Straight-lanced grasshopper	S2	0.04
12. Chinese mantis	PM1	0.12
13. Field cricket	KC1	0.13

PREPARATION OF ANTISERA

The immune sera were produced in rabbits, injected intravenously. Five milligrams of protein per kilogram body weight of rabbit was given in the first injection. Three more injections were given on alternate days, the quantity of material injected being doubled with each successive dose.

The rabbits were trial-bled seven days after the last injection. If the antisera were potent enough, final bleeding was accomplished on the eighth day. For the final bleeding, the blood was drawn directly from the heart of the anaesthetized rabbit. The blood so obtained was permitted to clot. After from seven to fourteen hours the clear serum was decanted off and centrifuged. The antiserum was sterilized by filtration in a Seitz filter; bottled in 5 cc. serum vials; and stored in the refrigerator until needed.

PREPARATION OF SPECIAL ANTIGENS AND ANTISERA

To determine the effects of lipoidal materials on insect precipitin reactions preparation of the antigens was altered. The macerated insects were expressed through fine bolting cloth to remove the chitin and then immediately lyophilized using the Florsduff-Mudd procedure (1935). The lyophilized material was then divided into two portions.

One portion was extracted with 0.85 per cent buffered saline using the proportion of 100 cc. of saline for 2½ grams of lyophilized roach. The saline-roach mixture was shaken for one hour, placed in the refrigerator overnight, shaken for thirty minutes more, and then centrifuged at 2500 r.p.m. for one hour. A portion of the slightly cloudy supernatant liquid was decanted and used as an antigen. The remaining supernatant liquid was cleared by sterile filtration through a Seitz filter. The sterile filtrate was bottled, under sterile conditions, in serum vials, and stored in the refrigerator. The antigen suspension was injected intravenously in the rabbit beginning with ½ cc. and using doubling doses on alternate days for four injections. Trial bleedings were performed seven days after the last injection. Final bleeding was accomplished on the eighth day, if the precipitin test titers were significant.

The second portion of the lyophilized material was extracted first to remove the lipids, using a modification of the Bloor (1928) technique. Absolute ethyl ether and absolute ethyl alcohol in the proportions of 3 : 1, were mixed into a solution, 100 cc. of which was used for each gram of lyophilized roach being treated. The Bloor's-roach mixture was shaken for one hour and placed in the refrigerator overnight. On the next day, the Bloor's solution was pipetted off, replaced with fresh Bloor's solution, and shaken again for one hour. This procedure was repeated once more. The lipid extracted roach material was filtered, dried at room temperature for 24 hours, and then extracted with saline and injected intravenously as described above.

TESTING OF ANTIGENS AND ANTISERA

Precipitin tests were made in two ways: (1) titrations were performed using the ring test technique (Boyden, 1926), and (2) measurements based on the turbidities of the reactions were taken by use of the Libby photronreflectometer (1938).

The photron'er (photronreflectometer) method was used essentially as outlined by Boyden and DeFalco (1943). One chief departure should be noted. If dilutions covering the entire range of reactivity between antigen and antibody are made, then the absolute antigen concentration in the initial dilution cell need not be considered. Subsequent dilutions of the antigen concentration must be made in a uniform manner, however. In these experiments each cell had an antigen concentration one-half that of the preceding cell in the dilution series. The respective volumes of antigen dilution and antisera contained in each cell were always kept constant; namely, 1.7 cc. of antigen dilution and 0.3 cc. of antiserum. The insect antigens were in most cases so weak that the undiluted antigens when reacted with undiluted antisera gave photron'er readings past the zone of maximum turbidity in the region of

antibody excess. The result was that under these conditions only a part of the curve of reaction could be obtained. In order to obtain a complete curve from zero in the antigen excess zone to zero in the antibody excess zone it became necessary to dilute the antiserum by an appropriate factor. Dilutions of one part antiserum to one part saline,

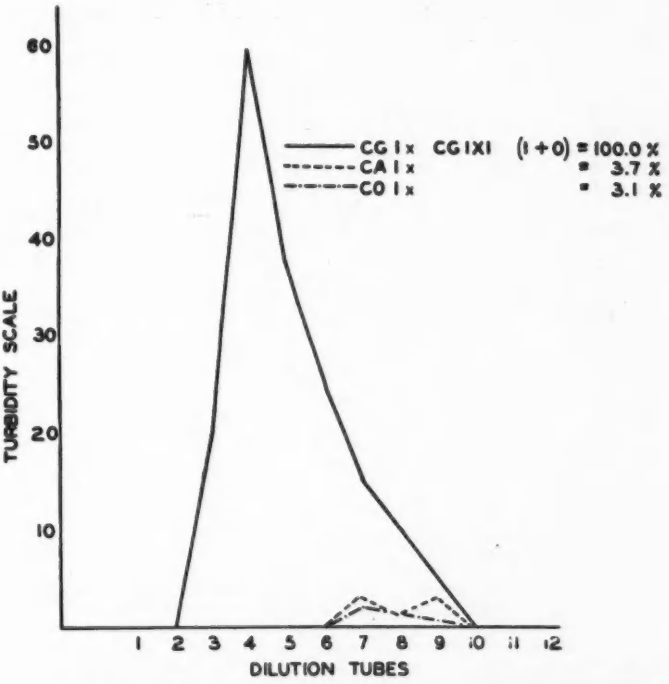


FIG. 1. A highly specific titration curve. The narrow width and sharpness of the anti-German roach serum (CG 1 X 1) curve when tested with its homologous German roach antigen, *Blatella germanica*, CG1, is indicative of a single antigen-antibody system. The heterologous reactions with other roaches, *Periplaneta americana* (American roach) CA1, and *Blatta orientalis* (Oriental roach) CO1, were barely significant.

or one part antiserum to two parts saline were sufficient in all cases to give complete curves.

With the ring test, standardization of the intitial dilution tube is essential for comparable results. The ratio of one part protein (as established by the Kjeldahl nitrogen determinations) to five hundred parts saline (1 : 500) was chosen for the first dilution tube. All subsequent dilutions were made as reported by Boyden and Noble (1933).

Clear, freshly prepared, antigens and antisera were used to perform the precipitin tests included in this paper.

From his experience the author feels the need of emphasizing certain points regarding the ring test method:

1. The exact protein concentration should be known in all antigen solutions in order for the reaction titers to be comparable.

2. Absolutely clear antigens must be used in every test. Very fine rings are easily lost in cloudy solutions.

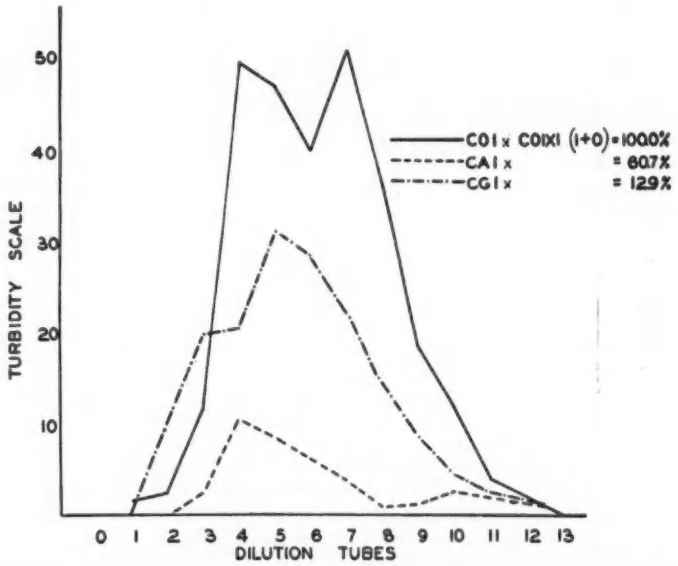


FIG. 2. The anti-Oriental roach serum (CO 1 X 1) showed the ability to distinguish other roach organisms, CA 1 (American roach) and CG 1 (German roach). The percentage values are indicative of the degree of correspondence between the roach antigens.

3. The layering of the antisera must be done with extreme care to obtain a sharp interfacial division.

4. Jarring the tubes must be avoided. Fine rings easily become diffuse and are lost because of this carelessness.

EXPERIMENTAL RESULTS

Relationships

Immune sera produced against members of the family Blattidae (The Roaches or Cockroaches) proved in every case, to be highly differentiating when used against members of that family. Each antigen induced the formation of a powerful antiserum. Reciprocal tests were

conducted and in no instance was there any variation in the order of relationship which these roaches showed to each other.

A study of figures 1, 2, and 3 indicates that the Oriental roach, *Blatta orientalis*, and the American roach, *Periplaneta americana*, are

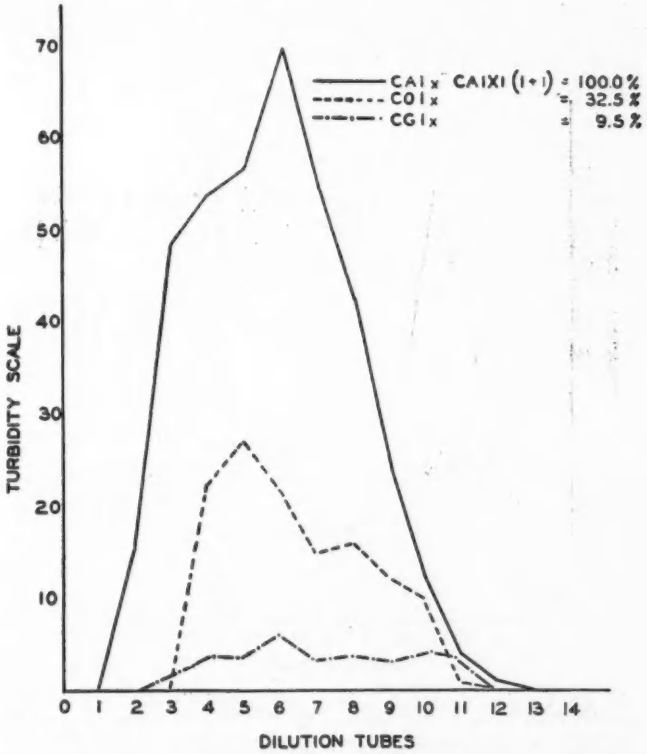


FIG. 3. These curves are the reciprocals of the tests in Figure 2. The percentage values between the American roach (CA 1) and the Oriental roach (CO 1) show a reduced correspondence. It will be noted, however, that the antiserum CA 1 X 1 against the American roach has been diluted with an equal part of saline. This treatment of the antiserum increases its specificity (Boyden and DeFalco, 1943) and the reduced activity is in accord with this principle.

more closely related to each other than to the German roach, *Blatella germanica*. The antiserum against the German roach was highly specific giving heterologous curves which were barely significant; a differentiation between the Oriental and American roaches using this antiserum was not possible. The anti-American and anti-Oriental

roach sera, however, were able to select out the German roach antigen with approximately equal sensitivity.

A second antiserum produced in response to an American roach antigen was less specific than the first antiserum and gave to the German roach antigen a heterologous reaction value of 51% (figure 4), as contrasted to the original value of 9.5% (figure 3). This behavior is not inconsistent with known facts concerning the reaction of different rabbits to the same antigen, all other factors remaining constant.

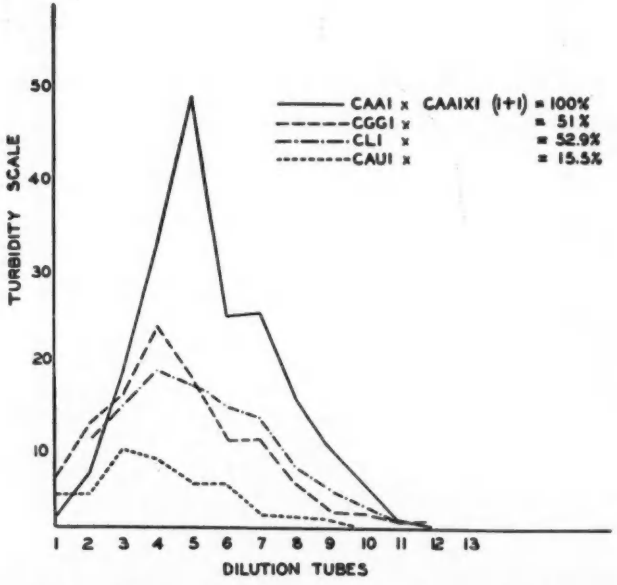


FIG. 4. The Tropical roach (CL 1) is about an equal distance from the American roach (CAA 1) as is the German roach (CGG 1). The percentage value between the American and German roaches serves to demonstrate the variability in rabbit response; compare with value given in Figure 3. CAu 1 is the Surinam roach.

The Tropical roach, *Leucophaea maderae*, shows approximately the same degree of reactivity to the American roach antiserum as does the German roach antigen (figure 4). The Surinam roach, *Pycnoscelus surinamensis*, is the most distant species to the American roach, of the forms tested.

The order of relationship established by the anti-German roach serum in figure 5, serves to demonstrate constancy of behavior found to be characteristic for all the extracted antigens. In these curves the American and Tropical roach exhibit approximately the same degree of

reactivity toward the German roach. As before, the Surinam roach is the least reactive of the roach species tested.

By comparing values in figures 6 and 7 it can be seen that the order of magnitude for the heterologous reactions is about the same. The

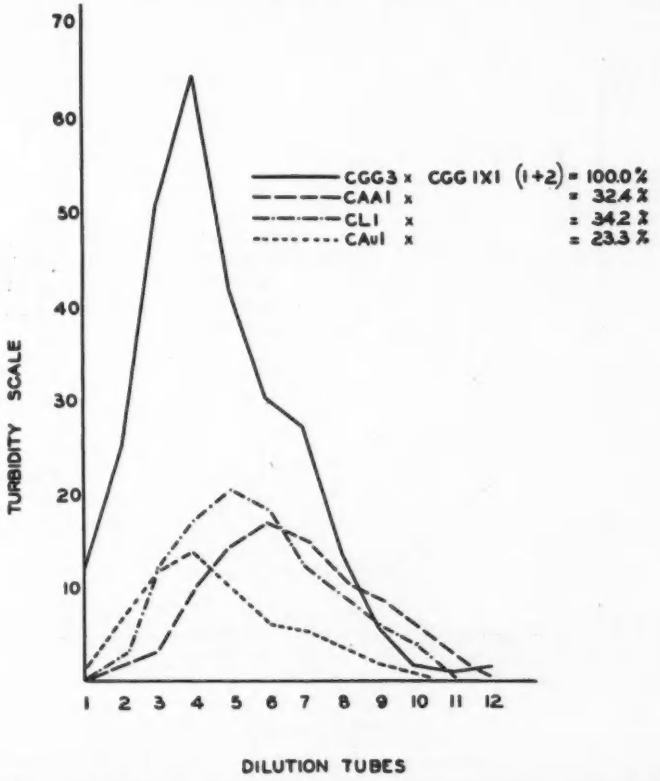


FIG. 5. The Surinam roach (CAu 1) is less reactive in the above graph and in Figure 4, than is the Tropical roach (CL 1). This constancy of behavior establishes the Surinam roach as more distant from the American and German roaches than is the Tropical roach.

Tropical roach and the Surinam roach show closer relationship to each other than the German or American roaches demonstrate to either one of them. It appears also that the German roach is slightly more closely related to the Tropical and Surinam species than is the American roach.

Intra-family relationships using the ring test or interfacial technique (figures 8, 9, 10 and 11) could only be established by diluting the

roach antisera with one or two parts saline, as indicated. By this means it was possible to reduce the relative concentrations of the reactants sufficiently to establish heterologous reactions whose titers did not equal that of the homologous reaction, as was the case when undiluted, or more concentrared antisera were employed. Even after the reduced heterologous titers were obtained, only the more closely related

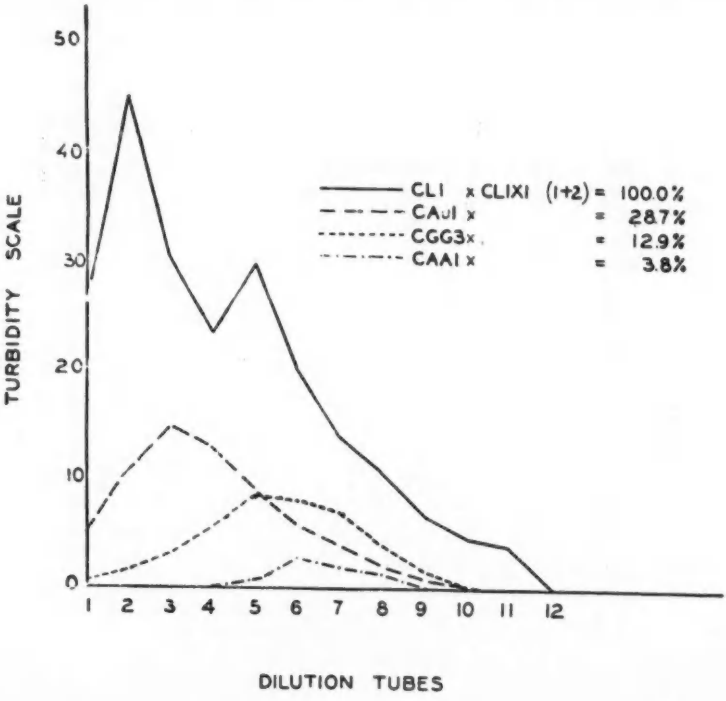


FIG. 6. The Tropical roach (CL 1) when reacted with its homologous antiserum shows a distinct bimodal curve. Only one other roach antigen and antiserum (Figure 2) demonstrated this characteristic. These curves indicate the presence of more than one kind antigen and probably more than one kind of antibody in the reaction.

species were selected out with a certainty. Other roach species were lumped together. One inconsistency in already established serological relationships would, at first glance, appear to exist in figure 9, where the Tropical roach exhibits a closer relationship to the German roach than does the American roach. DeFalco (1942) demonstrated how such a situation could arise when mixed antigens were used in performing ring test titrations. The existence of more than one antigenic substance in

the Tropical roach antigen solution is evident from the bimodal nature of a photron'er plot of the antigen, when titrated against its homologous antiserum (figure 6). It should be remembered that the titer of the ring test is the highest dilution of antigen at which a reaction between it and an antiserum of a given strength can be detected with the naked eye, and that this dilution is used in most comparative serology studies. At best the ring test titer presents but a single point on a whole dilution series and hence, cannot be regarded as a true index of the similarity between antigens being compared. The entire reaction curve of antigens and antisera must be plotted if more critical analyses of animal relationships using serological methods are to be obtained.

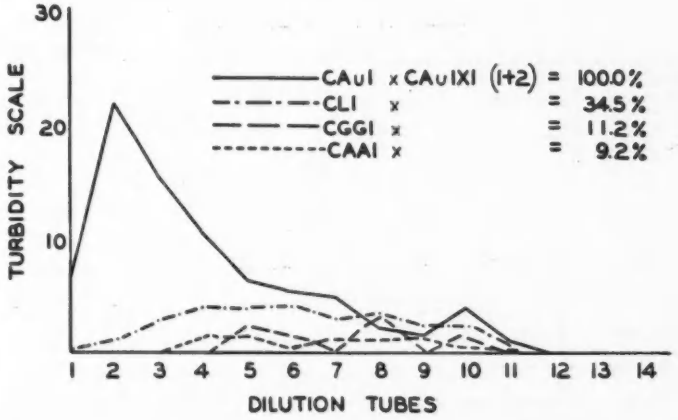
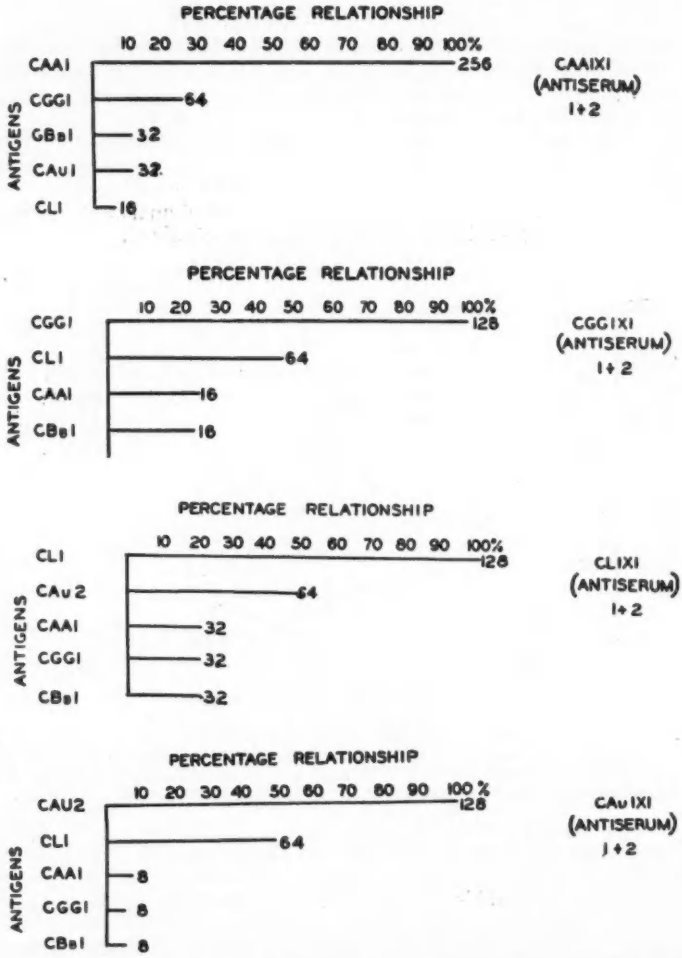


FIG. 7. The rarer forms, the Tropical roach (CL 1) and the Surinam roach (CAu 1) show a very definite and consistent (Figure 6) order of relationship with the more common forms. The American roach (CAA 1) is more distant from the Tropical and Surinam roaches than is the German roach (CGG L).

Once the limitations of the ring test are understood, it can be an effective serological tool in certain cases. Inter-family tests, for example, were undemonstrable using the photron'er with the antisera available (figure 12). Using the ring test technique, however, it was possible with undiluted antiserum, to obtain reactions to four different families in the insect order Orthoptera (figure 13). Of these, the Gryllidae (Crickets), and the Tettigonidae (Katydids) appear to be more closely related to the Blattidae (Roaches), than do the Acrididae (Locusts) and the Mantidae (Mantids). In a subsequent paper reciprocal tests will be described which establish more definitely these interfamily relationships. Classifications based on reactions related to a single locus, and on ring test results alone can lead to erroneous conclusions.



FIGURES 8, 9, 10, and 11. These charts are ring test reactions giving the degree of relationship between the various species of roaches in the family Blattidae. The lines show the percentage relationship between the specimens considered. The number following each line represents the titer of the reaction in thousands. For example, the number 64 represents one part antigen in 64000 parts of saline. Antisera were diluted with one or two parts saline, as indicated, to increase the specificity of the reactions.

KEY

CAA 1—American roach (*Periplaneta americana*).
CGG 1—German roach (*Blatella germanica*).
CL 1 —Tropical roach (*Leucophaea maderae*).
CAU 1 or
CAu 2 —Surinam roach (*Pycnoscelus surinamensis*).
CBb 1—Broad Wood-roach (*Parcoblatta lata*).

Lipids

The significance of lipid substances in the study of insect relationships is of interest, particularly when saline extracts of the insects are used for comparative studies. In some recent work with invertebrates, as reported by Wilhelmi (1940), and by Cumley (1940), the removal of

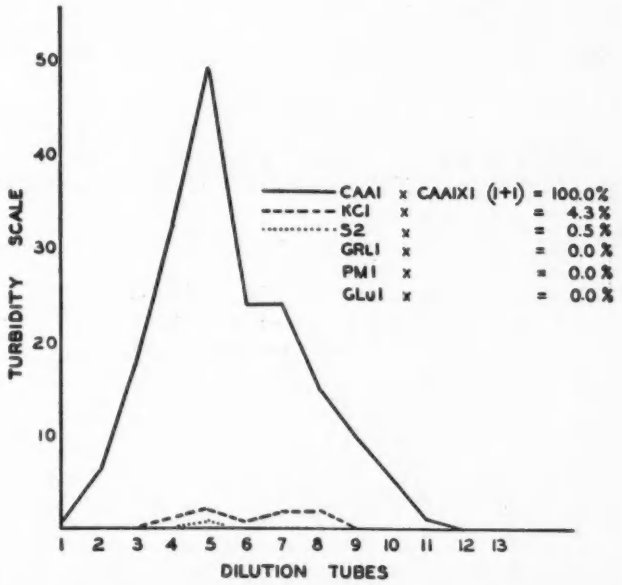


FIG. 12. Interfamily specificity is strikingly shown in this curve. Almost a complete exclusion of the other forms of Orthoptera is demonstrated. This is evidence that a wider gulf exists between families than exists between genera within a family. This is in accordance with morphological findings. The test when conducted with undiluted antisera still showed complete specificity. The homologous curve moreover was moved to the left, and only the region of antibody excess could be precipitated.

CAA 1—*Periplaneta americana* (American roach).
KC 1 —*Gryllus assimilis* (Common field cricket).
S 2 —*Conocephalus strictus* (Straight-lanced grasshopper).
GRl 1 —*Melanoplus femur-rubrum* (Red-legged grasshopper).
PM 1 —*Paratenodera sinensis* (Chinese mantis).
GLu 1 —*Rhomalea microptera* (Florida lubber grasshopper).

lipid substances has yielded antigens which appear to give remarkably consistent results.

Figures 14 and 15 show a comparison between the saline extract of a lyophilized roach preparation (salex), and the saline extract of a lipid extracted, lyophilized roach preparation (lipex). The salex and lipex preparations of these German roach antigens were equal in their capacity

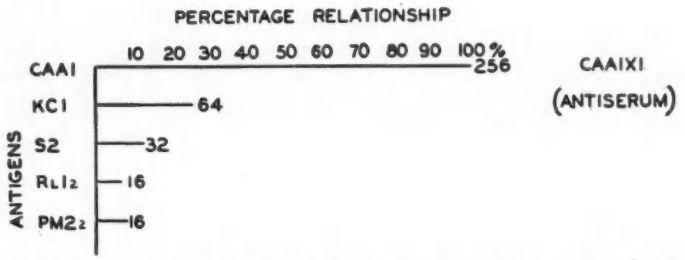


FIG. 13. Families within the order Orthoptera demonstrate different degrees of similarity to the Blattidae antigen. This chart, when compared with the same tests as performed on the photron'er (Figure 12), demonstrates the ability of the ring test to measure the titers of more distantly related forms. Dilution of the antiserum with one part saline made it completely specific.

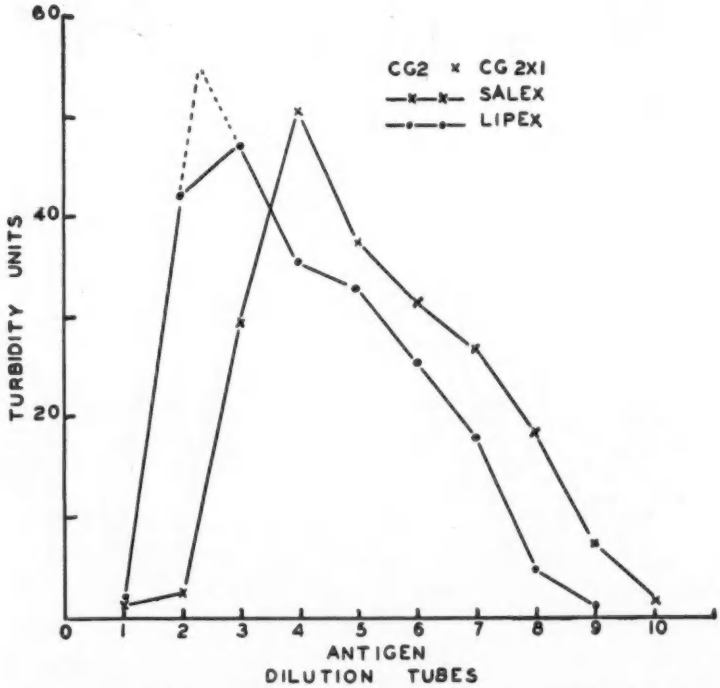


FIG. 14. The lipid-free curve (lipex) of the German cockroach (CG 2) antigen shows only a slight displacement to the left of the homologous saline extracted lyophilized roach (salex) curve. The dotted portion of the curve indicates the approximate position of the peak; it also emphasizes the essential similarity of the two curves. Both curves are of the same order of magnitude.

to react with an antiserum to either antigen. Both antisera produced against the salex and lipex antigens (German roach) were highly specific. Using the undiluted antiserum CG2X2 (German roach antilipex serum), a heterologous curve was obtained with salex and lipex preparations of the American roach. The lipex heterologous antigen showed only a slightly more amplified curve than the salex. Salex and lipex prepared antigens to the Oriental roach were also tested against the same (anti-lipex) antiserum, but did not react.

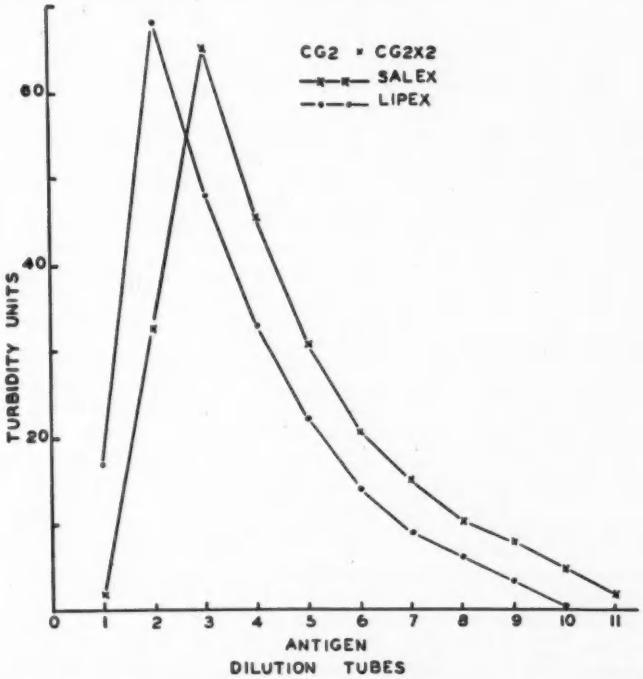


FIG. 15. The striking similarity of the homologous lipid-free antigen (lipex) and the saline antigen curves, indicates the presence of very similar antigenic substances in both extraction preparations. CG 2 are the German cockroach antigens and CG 2 X 2 the homologous antiserum made against the lipex antigen.

DISCUSSION OF EXPERIMENTS

A fundamental question challenging the validity of experiments using extracts from grindings of whole insects as a basis for systematic classification might rightfully be raised. It is simply this: Are the antigens prepared as described really comparable? Admittedly, comparisons using insect sera, or extracts of homologous structures or organs in the insect body would theoretically present a more critical basis for

comparison. However, the use of sera, or extracts of homologous organs are not always practical when small organisms are being considered.

As a preliminary study, antigens prepared as outlined in this paper can be regarded as comparable representatives of these species for several reasons: (1) the extraction procedure selects out only the more soluble materials, (2) the rabbit responds only to the better antigens. Differential antigenicity of proteins has been well established in other serological work. (Boyden and DeFalco 1943), (3) antibodies react specifically only with *corresponding* antigens, (4) reciprocal tests provide ample evidence for the validity of the relationships, (5) antigens prepared from different lots of the same species of insect and tested with an antiserum made against one of them gave homologous curve areas that were within the limits of error of the photron'er as applied to these tests.

The insect morphologist might also raise objections to the worth of reciprocal serological tests whose degree of correspondence varies to the extent found in the data given in this paper. It is common knowledge that the greatest variable in any given serological problem is the animal that produces the antibodies. The different percentage relationships between organisms as shown by the reciprocal tests are the result primarily of the variability of rabbit response, which in turn is a function of the animal's physiological condition. Several rabbits injected with the same antigen under uniform conditions could produce antisera (1) whose titration curve areas would differ, i. e., the strength of the antiserum produced against the same amount of antigen could be different for each animal, (2) whose titration curve shapes might be different, and (3) whose degrees of specificity could differ. Moreover, these three variables might assort themselves independently with respect to the behavior characteristics of a given antiserum. In all antisera tested, however, the relative order of the positions of the species tested were constant. Further explanation of the differences in antiserum behavior will not be considered in this paper. Boyden and DeFalco (1943) have presented considerable information describing the nature of antisera behavior in precipitin systems. The lack of exact correspondence of the reciprocal tests is not a valid reason for discrediting the use of extracts of whole organisms in establishing relationships, or for not employing serological methods to classify insects.

Occasionally two different species demonstrate the same degree of serological relationship to a third form. This definitely indicates that their relationship cannot be considered as linear. When more than three species are tested it has been shown (Boyden, 1934) that at least three dimensions are needed to assure proper interpretation. With a given organism serving as a locus all animals compared to it on the basis of their serologically active components would take positions in all dimensions of space around that locus. Thus in figure 5 the American roach (CAA1) and the Tropical roach (CL1) exhibit approximately equal serological relationships to the German roach (CGG1). It is obvious too in figure 6 that the American roach, of all the forms tested, presents the least amount of serological similarity to the Tropical roach. In order to accommodate these seemingly conflicting statements, more than a single plane of space must be considered in establishing relation-

ships. An analogy can be drawn by visualizing two cities, each equidistant from New York City, but with geographic distances between them which could be greater than, and as much as twice the distance of either one of them from New York City. In the latter instances all three cities would be in a straight line with New York City midway between the other two. The American and Tropical roaches must be oriented equidistant from the German roach locus but at the same time with a greater distance between them than between either one of them and the German roach locus.

SUMMARY

1. Serological comparisons of whole insect extractions were made using the "ring" or interfacial test, and the photoelectric measurement of turbidities developed in the precipitin reaction.

2. In general the relative intensities of these precipitin reactions ran parallel with the systematic position of the species compared.

3. Lipid extracted saline preparations of a lyophilized roach sample were compared with saline extracts of the same lyophilized roach materials, with no demonstrable differences being detected.

4. The validity of the use of extracts of whole organisms in establishing relationships is briefly discussed.

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A NEW SPECIES OF TENTHREDO FROM THE APPALACHIANS[1]

(Hymenoptera: Tenthredinidae)

LEWIS J. STANNARD, JR.
University of Illinois,
Urbana, Illinois

During the summer of 1946 a new species of *Tenthredo* was obtained from two localities, separated by several hundred miles, in the Appalachian mountains that traverse Pennsylvania. Later another female and two more males were studied which had been collected in 1939 from a more distant part of the Appalachian ranges in North Carolina and Tennessee. The specimens from Ohiopyle, Pennsylvania, were captured in a patch of jewel-weed at the edge of a dense, moist woods. Since most Tenthredo's are active fliers, the jewel-weed could be a "sitting" habitat and not necessarily the host in which oviposition occurs.

I wish to thank Dr. H. H. Ross for his confirmation that this species had not yet been described, for his advice, and for permitting me to use the Illinois Natural History Survey collection for reference. Also I am indebted to Dr. S. W. Frost of the Pennsylvania State College and to Dr. Marion E. Smith, of the Massachusetts Agriculture College for the loan of their material.

Tenthredo prosopa new species

Female.—Length 13.5 mm. Color almost entirely orange-yellow with some black and cream white markings. The following areas are black: a mask-like area between the compound eyes, fig. 1, apices of the mandibular teeth, lateral margins of antennal segments 1 and 2, and all of segments 3 to 9, and a fine edge around the ovipositor sheath. Cream white are: clypeus (except extreme median basal part), labrum, bases of the mandibles, and appendages of the mouth parts. A large white spot occurs above each hind coxa and on the lateral margins of the first abdominal tergite. The following areas are pale yellow: ventral portions of the mesopecta, apices of the coxae, trochanters, and a broad median band on the ventral segments of the abdomen. Tarsal claws tipped with red.

Wings hyaline; stigma, and marginal veins orange-yellow; remainder of the veins, black.

Structure typical for the *mellina* group. Inner margins of the antennal sockets strongly upraised to give a flanged appearance, the area immediately between sunken and flat; antennae long (8.5 mm.) and slender, fig. 2; head furrows deeply impressed, ridges prominent. Head generally polished; thoracic punctures weakly defined; scutellum

[1]Contribution No. 272 of the Department of Entomology, the University of Illinois, and the Illinois State Natural History Survey, Urbana, Illinois.

moderately convex, fig. 5; and the median portions of the mesoepisterna drawn out into a sharp angle.

Male.—Length 11 mm. Structure and color similar to female with the following exceptions: Black area on the head slightly more extended, including most of the inner, upturned part of the antennal sockets and tapering posteriorly to the postocellar furrows. The orange-yellow color fades into a pale white on the cheeks at the base of the mandibles. Tegulae, anterio-ventral corners of the pronotum, and most of the ventral segments of the abdomen paler than the rest of the body.

Holotype, female.—Ohiopyle, Pennsylvania, July 21, 1946, W. L. Brown, Jr., and Stannard. Deposited in the collection of the Illinois Natural History Survey.

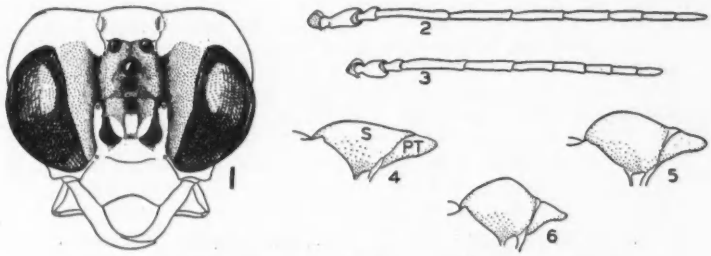

FIG. 1. *Tenthredo prosopa* n. sp. Antero-dorsal view of head.
FIG. 2. *T. prosopa*, antenna.
FIG. 3. *T. xantha*, antenna.
FIG. 4. *T. xantha*, scutellum and post tergite, lateral aspect.
FIG. 5. *T. prosopa*, scutellum and post tergite, lateral aspect.
FIG. 6. *T. mellina*, scutellum and post tergite, lateral aspect.
s—scutellum. pt—post tergite.

Allotype, male.—Same data as for holotype.

Paratypes.—Andrews Bald, North Carolina, June 11, 1939, 5200 feet, C. P. Alexander, 1 ♀; Mitchell Range, Bald Knob, North Carolina, June 22, 1939, C. P. Alexander, 1 ♂; Smoky Mountains, Tennessee, 6000 feet, June 6, 1939, C. P. Alexander, 1 ♂; Black Moshannon, Pennsylvania, July 6, 1946, S. W. Frost, 1 ♂. Deposited with the holotype and in the United States National Museum, the Pennsylvania State College, and the Massachusetts Agriculture College.

The paratype female from North Carolina is smaller than the holotype, about 12 mm. in length. The black band is present between the eyes but the upper limits are less extensive and it is lacking for the most part on the area around the ocelli. Furthermore, the venter of the abdomen is mostly pale.

The male paratypes vary in size from 10 to 11 mm. with the specimens from the southern range the smaller. The black band on the head does not manifest a uniform pattern although black is always present from the antennal furrows to the inner margins of the compound eyes.

Of the specimens that are available at the present time, the individuals from the northern localities show more black coloring on the head and are of a slightly larger size than those found farther to the south.

In existing keys this species will run to *T. mellina* Norton on the basis of the yellow-orange color, the convexed scutellum, and the long slender antennae. It can be separated from *mellina* by the black area between the eyes, by the dark antennae, by the absence of a yellow orbital margin, and by the moderate convexity of the scutellum, figs. 5 and 6. In the *xantha* group, some specimens exhibit a similar orange color but it is more of a chestnut orange. *T. xantha* Norton, lacks the large black mask on the head, the antennae are shorter, fig. 3, and the scutellum is flattened, fig. 4. *T. macgillivrayi* Smulyan and *T. vittata* Kirby may approach some *xantha* variants in color but can be excluded from this group because of the pronounced black band on their hind femora.

A GENERIC AND SUBGENERIC SYNOPSIS OF THE UNITED STATES ANTS, BASED ON WORKERS, by MARION R. SMITH. American Midland Naturalist, Vol. 37, No. 3, pp. 521–627, 1947.

This synopsis includes 87 genera and subgenera, all that are known to occur in the United States. It is based on the worker caste, which has received the main emphasis in ant taxonomy. Dr. Smith has presented the generic taxonomy of the males elsewhere (1943, Amer. Midland Nat., 30: 273–321).

The treatment is as complete as anyone could wish. Besides keys, each genus and subgenus has a full description, a beautiful figure of a side view of a worker, a list of the included species and minor forms of the United States, a statement on distribution and biology, and a list of the important literature. An appendix to the paper includes a glossary of terminology and a bibliography of the ant literature for the various states.

Ant taxonomy has had the attention of a number of able men, and present knowledge of the Nearctic genera is relatively complete and sound. Dr. Smith's contribution is not in new taxonomic information and ideas, but in the careful selection and adaptation of the results of former research, seasoned with the wide and detailed knowledge of an experienced specialist. The paper is recommended as indispensable to all students of Nearctic ants and as a model for other generic revisions. We understand that separates can be purchased from the Editor of the American Midland Naturalist, University of Notre Dame, Notre Dame, Indiana.—H. TOWNES.

A REVISION OF THE NORTH AMERICAN ANTS OF THE GENUS MYRMICA LATREILLE WITH A SYNOPSIS OF THE PALEARCTIC SPECIES. I.

NEAL A. WEBER

Among the best known and most interesting species of ants are those belonging to the genus Myrmica. Common and conspicuous insects, they have long figured in the popular literature of Europe as "red ants," or "fourmis rouges." In general habitus they may be regarded as typical ants: they are of medium size, with 12-jointed antennae (13-jointed in the male), possess a two-jointed pedicel, sharply separating the thorax and gaster, and are inconspicuously colored in various shades of blackish-, reddish- or yellowish-brown. The species are terrestrial, developing colonies of medium size, which are to be found under stones, logs or grass roots. A large part of our information on ant morphology is due to Charles Janet who, between 1892 and 1907, chose *Myrmica rubra* for many of his studies, probably because it was a typical and common ant. Wasmann and Donisthorpe have recorded 79 species of myrmecophiles occurring with ants of this genus in diverse relationships.

Students of ants dealing with a genus numerous in species and variable individuals come to think of it as being the *crux myrmecologorum*. This became my attitude while studying Myrmica under W. M. Wheeler in 1932–34. At that time the collection of this great master had not been divided between Harvard University and the American Museum of Natural History. In addition, the state of the world made it easy for me to acquire collections from myrmecologists in other countries and from other American institutions.[1] There had never been a general revision, so that collections generally consisted chiefly of unidentified specimens.

This great wealth of material, probably the largest collection of ants of this genus ever to have been brought together in one place, posed embarrassing problems. In a small collection from scattered localities it would have been relatively easy to have assigned the ants various names, using new names for specimens which differed more or less from previously recognized forms. In a very large collection, however, this is not so easy because the extremes tend to be connected by intermediate forms. It also seemed inescapable that several forms, called "varie-

[1]I am particularly obliged to the following for loan of material: Dr. W. M. Mann and the United States National Museum (U.S.N.M., in the locality lists); Drs. A. C. Cole, Jr., W. S. Creighton, M. R. Smith, Mary Talbot and G. C. Wheeler; Dr. H. H. Ross and the Illinois State Natural History Survey (Ill. Nat. Hist. Surv., in the locality lists); Dr. F. P. Ide and the Royal Ontario Museum of Zoology (R.O.M.Z., in the locality lists); the late Dr. E. W. Wheeler. My thanks are also due the following European myrmecologists: the late Dr. Carlo Menozzi and Mr. Bruno Finzi, of Italy; Dr. Stepan Soudek, of Czechoslovakia; Dr. H. Kutter, of Switzerland; Mr. H. K. Donisthorpe and the British Museum (Natural History); Dr. K. Fösswald, of Germany, and Dr. A. Stärcke, of Holland.

ties," which had long rested in the literature were not valid. Although these included several created by Wheeler in 1907 he concurred in my opinion. Fortunately nearly the entire type series was available in his forms and cotypes represented those described by others.

Little time could be devoted to these ants in the intervening years, but the frequent requests for identifications for use in other studies have added new records and necessitated publication of a short paper in 1939 to validate manuscript names. Also, early in 1939, copies of my keys to workers, females and males of the North American forms were distributed to Drs. A. C. Cole, W. S. Creighton, M. R. Smith, M. Talbot and G. C. Wheeler.

Since the North American Myrmicas are closely related to those of Europe and Asia a study of the fauna of these regions was necessary. Unfortunately Bondroit and others created numerous forms which cannot be evaluated from the descriptions alone. Emery, Wheeler and others were highly skeptical of many. In the absence of much palaearctic type material the original plan for a world revision has been abandoned. The palaearctic synopsis will assist future workers, however, in view of the 40 years which have elapsed since there has been any attempt at treating this fauna as a whole. Forel keyed the Swiss Myrmicas, Ruzsky the Russian forms known in 1905, Emery the palaearctic species in 1908 and Finzi the European forms in 1926. Ern. André, Stärcke and Santschi have treated parts of the European fauna. Dr. Wheeler had understandably refrained from this task for North America and had assigned it to me as my initial taxonomic problem.

CLASSIFICATION

In the 10th edition of the Systema Naturae (1758), Linnaeus gave the first name, *Formica rubra*, to a member of this genus. The generic name, from the Greek "*μυρμηξ*"—ant, dates from 1810, when Latreille made the Linnaean species the type of this genus. For the remainder of the nineteenth century Myrmica was made a receptacle for many species with two-jointed pedicel, which are now removed to other genera.

Since the worker is the caste usually collected, it has naturally been used as the basis of our classification. For the present treatment, especially of the North American species, I have had a sufficient number of males and females associated with the workers to be able to use the three castes together in determining relationships. The genitalia of the male have proved to be of much aid and especially the volsellae, the paired hook-like appendages on each side of the medial sagittae constituting the penis.

Every North American myrmecologist has found the workers to be highly variable. To repeat my 1939 statement: "it should be emphasized that frequently no satisfactory determination can be made of specimens unless at least the male caste is present with workers from the same nest." This variability is not unique in Myrmica, however, for some species of Solenopsis, Crematogaster, Attini and Camponotus, to name a few, are similar.

Variability in color may sometimes be explained on the basis of temperature and humidity. An ant, such as *Myrmica brevinodis*, reared under cool and humid conditions may be darker than one of the

same species reared under warm and dry conditions. In a given locality where both ***brevinodis*** and ***sabuleti americana*** occur, the former is darker in color and likely to be found in the cooler and damper spots, the latter on the better drained, hence dryer, and sunnier places. ***Sabuleti nearctica***, in its type locality and generally where taken in North Dakota, is a dark subspecies found in cool, damp, sites; ***americana***, often occurring close by but in warmer and drier areas, is paler.

The revision follows the plan indicated in the 1939 paper of treating as species certain forms which some earlier authors had considered to be subspecies or varieties of ***rubra*** or ***scabrinodis***, the two generalized species. Indeed, half of the 124 described forms known in 1934 were called subspecies or varieties of ***scabrinodis***. The term "variety" was abandoned by myself years ago although it may have utility in some cases. In fact, I had used it only four times previously for new ants. Originally I had followed Dr. Wheeler in using quadrinomials in Myrmica. Recent practice in Europe also is to elevate certain forms, although some workers are still creating "varieties." Holgersen (1940, 1942, 1944) regards ***ruginodis***, ***laevinodis***, ***scabrinodis***, ***rugulosa***, ***sulcinodis***, ***lobicornis***, ***schencki*** and ***sabuleti*** as distinct species in Norway. Stärcke (1942 a and b, 1943) similarly regards these as distinct species in Europe. Donisthorpe (British Ants, 1927) has long considered those of the above forms occurring in Great Britain, except ***sabuleti***, as "good though closely allied species."

The varietal status is here retained, however, for three North American ants which were so originally described and which future study may show to be three modern instances of importation from Europe, thus not deserving to be named at all. Certain doubtful or incompletely known palaearctic varietal names are also provisionally retained. A number of the forms from Europe are not described, but references are given to them. It is felt that they are the result of hair-splitting distinctions, which if consistently adopted would lead to the giving of a new name to almost every individual ant. This, obviously, does not subserve the purposes of classification.

For additional bibliography and synonymy prior to 1893, see the Catalogus Hymenoptorum (Dalla Torre, 1893) and prior to 1922, the Genera Insectorum (Emery, 1922).

AFFINITIES

The genus most nearly related to ***Myrmica*** is ***Manica*** Jurine (Wheeler emend.) which has been considered a subgenus of ***Myrmica***. I believe, however, that it would be better to regard it as a distinct genus, because of the following peculiarities:

The epinotum of the worker is unarmed instead of possessing distinct spines.

The teeth on the mandibles of the worker are more numerous and smaller.

The male has worker-like mandibles, whereas in ***Myrmica*** these organs are weaker and have fewer teeth.

The genitalia of the male can be readily distinguished from those of any ***Myrmica*** by the volsellae, which have a distinct lobe-like prolongation of the angle opposite the hook. The nearest approach to this

characteristic is found in *Myrmica rubra* (L.) in which, however, the prolongation is acutely angular. The genus *Manica* includes one Eurasian species, *M. rubida* (Latr.), and five American species, *aldrichi* Wheeler, *bradleyi* Wheeler, *hunteri* Wheeler, *mutica* Emery, and *parasitica* Creighton, parasitic upon *bradleyi*. The species, both in Europe and in North America, inhabit mountainous regions but are found only at moderate elevations nesting in comparatively dry and sandy situations.

Next to *Manica* the genus *Aphaenogaster* Mayr seems closest to *Myrmica* but differs clearly in the simple posterior tibial spurs, in slender habitus and in having the petiole always distinctly pedunculate. The genitalia of the male, nevertheless, show that *Aphaenogaster* is fairly close to some forms of *Myrmica scabrinodis* Nyl. and the relationship between the two genera may prove to be even closer when the males of *M. ritae* Emery and *margaritae* Emery are discovered.

FOSSIL RECORD

The fossil record of *Myrmica* is limited to one species, *M. longispinosa* Mayr., of the Baltic Amber (Oligocene), known from the holotype and one additional specimen identified by Dr. Wheeler (1914, pp. 59–60). Mayr believed it to be closely related to the recent *M. sulcinodis* Nyl. *Nothomyrmica intermedia* Wheeler, from the Baltic Amber, closely resembles *Myrmica* and was excluded from that genus only because it lacks spurs on the middle and hind tibiae. Thus far no *Myrmica* has been taken in the Florissant shales of Colorado (Miocene) or other North American deposits, although Dr. Carpenter (1930) has described several species of *Aphaenogaster* and other Myrmicinae from the former locality. As he has shown, the *Myrmica* sp. of Scudder from the Green River formation (Middle Eocene) is not a *Myrmica*, nor, indeed, a Formicid.

DISTRIBUTION

The species of *Myrmica* are holarctic, occurring in Asia from Northern Siberia to Formosa, the mountains of Burma, Persia and in the Caucasus; in Europe from Scandinavia to Greece, Italy and Spain; in North America from the Arctic Circle to the highlands of Mexico. There are two North African records in the literature. Forel cites *M. laevinodis* from Algerian gardens and Santschi (1931) lists the mountains of Tunis and the Iberian Peninsula as the range of *M. scabrinodis* var. *aloba* Forel. Dr. C. Menozzi has sent me several workers of *M. scabrinodis* subsp. *rolandi* Bond. from Asni, Morocco. These two forms of *scabrinodis* are widespread in the Iberian Peninsula, but whether they have been introduced into North Africa by human agencies or by winged fecundated females carried by winds across the Straits of Gibraltar, is not known. Apparently they have existed in North Africa for some time since both localities are many miles inland. No forms even closely related to *Myrmica* have been taken in Ethiopia, Australia or South America.

COMPARISON OF THE PALEARCTIC AND NEARCTIC SPECIES

Before proceeding to a discussion of the origin of the species of Myrmica of the two continents, the forms of these two major divisions

of the Holarctic Region may be compared. Unfortunately, many of the palearctic forms are known only from such brief and inadequate descriptions that their status cannot be accurately determined. Below are listed, however, the described forms.

PALEARCTIC	NEARCTIC
Myrmica rubra	*M. laevinodis* var. *bruesi*
Myrmica rubra var. *khamensis*	
Myrmica rubra var. *kotokui*	*M. laevinodis* var. *champlaini*
Myrmica rubra var. *orientalis*	*M. laevinodis* var. *neolaevinodis*
Myrmica rubra var. *silvestrii*	
Myrmica rubra subsp. *yoshiokai*	
Myrmica rubra var. *ruginodo-laevinodis*	
Myrmica laevinodis	
Myrmica laevinodis var. *europaea*	
Myrmica laevinodis var. *minuta*	
Myrmica laevinodis var. *tenuispina*	
Myrmica symthiesi	
Myrmica smythiesi var. *bactriana*	
Myrmica smythiesi subsp. *cachmiriensis*	
Myrmica smythiesi cachmiriensis var. *lutescens*	
Myrmica smythiesi subsp. *carbonaria*	
Myrmica smythiesi subsp. *dshungarica*	
Myrmica smythiesi subsp. *exigua*	
Myrmica smythiesi var. *fortior*	
Myrmica smythiesi subsp. *himalayana*	
Myrmica smythiesi subsp. *hecate*	
Myrmica smythiesi var. *rupestris*	
Myrmica rugosa	
Myrmica rugosa subsp. *arisana*	
Myrmica rugosa var. *debilior*	
Myrmica rugosa var. *kirgisica*	
Myrmica aimonis-sabaudiae	
Myrmica dicaporiaccoi	
Myrmica tibetana	
Myrmica tibetana subsp. *chinensis*	
Myrmica tibetana var. *furva*	
Myrmica commarginata	
Myrmica inezae	
Myrmica pachei	
Myrmica kurokii	
Myrmica kurokii subsp. *helleri*	
Myrmica kurokii var. *sontica*	
Myrmica kurokii subsp. *tipuna*	
Myrmica kozlovi	
Myrmica kozlovi subsp. *mekongi*	
Myrmica kozlovi subsp. *ruzskyi*	
Myrmica kozlovi subsp. *subbrevispinosa*	
Myrmica bergi	
Myrmica bergi var. *barchanica*	
Myrmica bergi var. *divergens*	
Myrmica bergi subsp. *persiana*	
Myrmica bergi kamyschiensis	
Myrmica sulcinodis	
Myrmica sulcinodis var. *nigripes*	
Myrmica sulcinodis var. *sulcinodo-ruginodis*	
Myrmica sulcinodis var. *sulcinodo-rugulosa*	
Myrmica sulcinodis var. *sulcinodo-scabrinodis*	
Myrmica sulcinodis subsp. *vicaria*	
Myrmica myrmecophila	
Myrmica lobicornis	*M. lobicornis* subsp. *fracticornis*
Myrmica lobicornis var. *alpina*	
Myrmica lobicornis var. *angustifrons*	

PALEARCTIC	NEARCTIC
Myrmica lobicornis var. *apennia*	
Myrmica lobicornis var. *arduennae*	
Myrmica lobicornis var. *deplanata*	
Myrmica lobicornis var. *foreli*	
Myrmica lobicornis var. *jessensis*	
Myrmica lobicornis var. *lissahorensis*	
Myrmica lobicornis var. *littoralis*	
Myrmica lobicornis var. *lobulicornis*	
Myrmica lobicornis var. *pyrenaea*	
Myrmica puerilis	
Myrmica sabuleti	*M. sabuleti* subsp. *americana*
Myrmica sabuleti var. *lonae*	*M. sabuleti* subsp. *hamulata*
Myrmica sabuleti var. *pilosiscapus*	*M. sabuleti* subsp. *nearctica*
Myrmica sabuleti var. *spinosior*	*M. schencki* subsp. *emeryana*
Myrmica schencki	*M. schencki* subsp. *spatulata*
Myrmica schencki var. *brunescens*	*M. schencki* subsp. *tahoënsis*
Myrmica schencki var. *burtshak-abramovitschi*	
Myrmica schencki var. *kutteri*	
Myrmica schencki var. *obscura*	
Myrmica schencki var. *plana*	
Myrmica schencki var. *starki*	
Myrmica schencki var. *salina*	
Myrmica rugulosa	
Myrmica rugulosa var. *hellenica*	*M. brevinodis*
Myrmica rugulosa var. *kievensis*	*M. brevinodis* subsp. *sulcinodoides*
Myrmica rugulosa var. *ruginodiformis*	*M. brevinodis* subsp. *kuschei*
Myrmica rugulosa var. *rugulosa-scabrinodis*	*M. brevinodis* subsp. *brevispinosa*
Myrmica rugulosa var. *slobodensis*	*M. brevinodis* subsp. *discontinua*
Myrmica rugulosa subsp. *limanica*	*M. scabrinodis* subsp. *mexicana*
Myrmica rugulosa limanica var. *strandi*	
Myrmica scabrinodis	
Myrmica scabrinodis var. *scabrinodo-lobicornis*	
Myrmica scabrinodis var. *kaszenkoi*	
Myrmica scabrinodis var. *ahngeri*	
Myrmica scabrinodis var. *aloba*	
Myrmica scabrinodis var. *angulinodis*	
Myrmica scabrinodis subsp. *eidmanni*	
Myrmica scabrinodis subsp. *granulinodis*	
Myrmica scabrinodis subsp. *lacustris*	
Myrmica scabrinodis subsp. *rolandi*	
Myrmica scabrinodis rolandi var. *reticulata*	
Myrmica scabrinodis subsp. *rugulosoides*	
Myrmica scabrinodis rugulosoides var. *striata*	
Myrmica scabrinodis var. *sancta*	
Myrmica scabrinodis subsp. *saposhnikovi*	
Myrmica scabrinodis saposhnikovi var. *baikalensis*	
Myrmica scabrinodis subsp. *stangeana*	
Myrmica scabrinodis var. *turcica*	
Myrmica scabrinodis subsp. *ussuriensis*	
Myrmica scabrinodis var. *vandeli*	
Myrmica scabrinodis subsp. *wesmaeli*	
Myrmica forcipata	
Myrmica ravasinii	
Myrmica moravica	
Myrmica myrmecoxena	
Myrmica margaritae	
Myrmica margaritae var. *pulchella*	
Myrmica ritae	*M. wheeleri*
Myrmica ritae subsp. *formosae*	*M. punctiventris*
Myrmica ritae subsp. *indica*	*M. punctiventris* subsp. *pinetorum*
Myrmica ritae subsp. *serica*	

Of the 137 described forms, only 19, or 14 per cent, are nearctic. These figures show a striking preponderance of palaearctic forms. Many of the European names, however, have been coined for small variations in the workers which I have considered, in the North American collection, to be normal variants of a single form.

A more accurate analysis of the forms of the two regions may be made from the two following lists. The first includes only those forms which are closely allied in all three castes or clearly related where only the worker caste is known:

PALEARCTIC	NEARCTIC
M. laevinodis	*M. laevinodis* varieties *bruesi* *champlaini* *neolaevinodis*
M. lobicornis forms	*M. lobicornis* subsp. *fraticornis*
M. scabrinodis	*M. scabrinodis* subsp. *mexicana*
M. sabuleti	*M. sabuleti* subsp. *americana* *hamulata* *nearctica* *spatulata*
M. schencki	*M. schencki* subsp. *emeryana*

The second list, which follows below, includes those species which are distinctly different. I must omit species from this list which were described inadequately, or of which I have not seen specimens. I am also omitting the two supposedly parasitic species.

PALEARCTIC	NEARCTIC
M. kurokii	*M. punctiventris*
M. margaritae	*M. wheeleri*
M. moravica	
M. pachei	
M. ritae	
M. rugosa	
M. smythiesi	
M. sulcinodis	

From the two selected lists presented above it will be seen that, of the fifteen distinctly different species, only five are common to the entire Holarctic Region. One of these, *M. laevinodis*, is included because it has three varieties, *bruesi*, *champlaini*, and *neolaevinodis*, described from the northeastern coast of North America. They may be importations. Another is included (*M. scabrinodis*) because of a subspecies in Mexico (*mexicana*).

Of the remaining ten species, two are peculiar to the Nearctic Region. It is a mere coincidence that this fraction corresponds somewhat with the 14 per cent arrived at by taking all of the described forms at their face value.

The remaining eight species are peculiar to the Palaearctic Region. One is restricted to southeastern Europe (*M. moravica*); another, *M. sulcinodis*, is widely distributed in Eurasia; the remaining six are peculiarly Asiatic. Of these latter species three, *margaritae*, *ritae*, and *kurokii* are restricted to eastern Asia.

ORIGIN OF THE SPECIES OF MYRMICA

To summarize, then, we may say that of the several distinct species of *Myrmica*, the three most widely distributed and variable species, omitting *laevinodis* and *scabrinodis*, are truly holarctic; two are more or less widely distributed; two species are nearctic; one is of southeastern European provenience, while the remaining six are peculiarly Asiatic.

The single fossil record from the Baltic Amber proves that the genus was established by the Oligocene. It seems probable that the genus was holarctic during the Early Tertiary for conditions were mild and communication between the Palaearctic and Nearctic Regions is undoubted.

Such a holarctic distribution during preglacial times would explain the present distribution of the species. The most specialized species, which are now found in eastern Asia, may have had a wider distribution but became limited to the southern and eastern part of their range during the Pleistocene. The two nearctic species, one now found on the Atlantic Coast, the other in the mountains of Arizona, could have been survivors of the glaciation, the former in the southern part of its range, the Southern Appalachians, the latter about where it now is, since that region has probably not undergone extensive glaciation. The widespread extension of the many forms of *M. scabrinodis* could have taken place after the Pleistocene. In the Palearctic Region they could have spread from eastern Asia, in the Nearctic Region from a haven in the southern Rocky Mountains. The great variability of such species as *M. rubra* and *scabrinodis* may be due to such a comparatively recent restocking of the major part of the Holarctic Region. Perhaps this influx of ants following the recession of the glaciers and reaching into new and varied environments has led to modifications of structure. For such an ancient and conservative group of animals as the ants, the time since the Pleistocene may not have sufficed for the stabilization of certain structural modifications. This would account for our finding so many puzzling series of intermediate forms at the present time.

KEY TO THE NORTH AMERICAN SPECIES AND SUBSPECIES OF MYRMICA WORKERS

1. Gaster punctate 2
   Gaster smooth 3
2. Length 4–4.7 mm.; epinotal spines about 1½ times the distance between their bases and deflected apically ..... **punctiventris**
   Length 3.5–3.9 mm.; epinotal spines only slightly longer than the distance between their bases, not deflected apically .. **punctiventris** subsp. **pinetorum**
3. Antennal scape bent angularly at the base, the bend equipped with a tooth or lamina 4
   Antennal scape evenly bent, not equipped with a tooth or lamina 11
4. Antennal scape with a lamina completely around the bend and prolonged along the posterior side to an appreciable extent 5
   Antennal scape different 7
5. Posterior extension of the lamina projected backwards near the base in an acute tooth or hook ..... **sabuleti** subsp. **hamulata**
   Lamina otherwise 6
6. Bend of the scape with a high, suberect lamina at the base; ventral margin of postpetiole nearly flat (Fig. 1) ..... **sabuleti** subsp. **americana**
   Bend of the scape with a low, thickened ridge at the base, posteriorly prolonged along the side in a horizontal and much wider extension, **sabuleti** subsp. **nearctica**

7. The bend with a high, thin lamina produced along the anterior side and downward, where deflected posteriorly to the base of the scape (Fig. 2), **schencki** subsp. **emeryana**
   Bend of the antennal scape otherwise 8
8. Bend, from above, with a broad, spatulate extension of the lamina medially and slightly upwards ..... **schencki** subsp. **spatulata**
   Bend of antennal scape otherwise 9
9. Antennal scape at the bend laterally compressed, i.e., laterally in the same sense as when used regarding the head, with a small transverse ridge across the bend ..... **scabrinodis** subsp. **mexicana**
   Antennal scape dorso-ventrally compressed at the bend and with a small tooth or lamina 10
10. Length 4–6 mm.; epinotal spines projected backwards at about 30° (Fig. 3) ..... **lobicornis** subsp. **fracticornis**
    Length 3.3–4 mm.; epinotal spines projected backwards at 40°–55°; thorax much paler than head and gaster ..... **schencki** subsp. **tahoënsis**
11. Epinotal spines much shorter than the declivity ventral to them 12
    Epinotal spines nearly as long to longer than the declivity ventral to them, or body strongly shining 14
12. Antennal scape ventral and median to the bend with a distinct keel on the postero-medial margin; body very finely sculptured, **brevinodis** subsp. **discontinua**
    Bend of scape with a faint indication of a posteromedial keel or tooth 13
13. Epinotal spines deflected apically ..... **wheeleri**
    Epinotal spines not deflected apically ..... **brevinodis** subsp. **brevispinosa**
14. Body strongly shining, sculpturing largely smooth 16
    Body largely dulled by sharp and deep sculpturing 15
15. Head and gaster dark brown to black, thorax and appendages red-brown, **brevinodis** subsp. **sulcinodoides**
    Color lighter ..... **brevinodis** and its subsp. **kuschei** of Alaska
16. Medial funicular joints quite as broad as long 17
    Medial funicular joints longer than broad ..... **laevinodis** var. **bruesi**
17. Epinotal spines as broad at the base as long ..... **laevinodis** var. **champlaini**
    Epinotal spines longer ..... **laevinodis** var. **neolaevinodis**

KEY TO THE NORTH AMERICAN SPECIES AND SUBSPECIES OF MYRMICA FEMALES

1. Gaster punctate 2
   Gaster smooth 3
2. Length 5–5.7 mm.; epinotal spines long and curved slightly downwards, **punctiventris**
   Length 4.7–5 mm.; epinotal spines short and straight, **punctiventris** subsp. **pinetorum**
3. Antennal scape bent angularly at the base and equipped with a dorsal tooth or lamina 4
   Antennal scape evenly bent, not equipped with a dorsal tooth or lamina 11
4. Antennal scape with a lamina completely around the bend and prolonged along the posterior side to an appreciable extent 5
   Antennal scape different 7
5. Posterior extension of the lamina projected backwards near the base in an acute tooth or hook ..... **sabuleti** subsp. **hamulata**
   Lamina otherwise 6
6. Bend of the scape with a high, suberect lamina at the base, **sabuleti** subsp. **americana**
   Bend of the scape with a low, thickened ridge at the base, posteriorly prolonged along the side in a horizontal and much wider extension, **sabuleti** subsp. **nearctica**
7. The bend with a high, thin lamina produced along the anterior side and downward, where deflected posteriorly to the base of the scape, **schencki** subsp. **emeryana**
   Bend of the antennal scape otherwise 8
8. Bend, from above, with a broad spatulate extension of the lamina medially and slightly upwards ..... **schencki** subsp. **spatulata**
   Bend of antennal scape otherwise 9

9. Antennal scape at the bend laterally compressed, i.e., laterally in the same sense as when used regarding the head, with a small transverse ridge across the bend ..... **scabrinodis** subsp. **mexicana**
Antennal scape dorso-ventrally compressed at the bend and with a small lamina 10
10. Antennal scape with a lamina; length 4.7–6.4 mm.; pronotum coarsely reticulate anteriorly ..... **lobicornis** subsp. **fracticornis**
Not so 11
11. Antennal scape with a lamina; length 4.5–5 mm.; pronotum transversely rugose ..... **schencki** subsp. **tahoënsis**
Not so 12
12. Length 4.5–5.2 mm.; thorax with moderately abundant, fine and acute hairs ..... **wheeleri**
Size larger 13
13. Antennal scape distinctly compressed at the base and with a slight dorso-median keel; length 5.3–6.3 mm.; color largely brownish red, **brevinodis** subsp. **brevispinosa**
Not so 14
14. Length about 5.6 mm.; color of body dark brown, appendages yellow brown; scutum of mesonotum with coarse, shallow pits at the base of the sculpturing ..... **brevinodis** subsp. **kuschei**
Not so 15
15. Color of body blackish brown, appendages brown; length 6.3–7.2 mm., **brevinodis** subsp. **sulcinodoides**
Not so 16
16. Antennal scapes stout; antero-median and parapsidal dark brown blotches on the mesonotum, pronotum lighter ..... **brevinodis**
Antennal scapes slender; pronotum dark brown, scutum of mesonotum much paler and with a posteromedian darker blotch .. **laevinodis** var. **bruesi**

The females of *brevinodis* subsp. *discontinua* and *laevinodis* varieties *neolaevinodis* and *champlaini* are unknown.

KEY TO THE NORTH AMERICAN SPECIES AND SUBSPECIES OF MYRMICA MALES

The genitalia, particularly the volsellae, offer more reliable characters for separating the species and subspecies, but cannot easily be put in a Key.

The "Antennal scape length" is given as the number of succeeding joints which, together, are as long as the scape.

1. Gaster punctate 2
Gaster smooth 3
2. Antennal scape length 6 ..... **punctiventris**
Antennal scape length 2 ..... **punctiventris** subsp. **pinetorum**
3. Antennal scape length 2 4
Antennal scape length 3–7 6
4. Antennal scapes distinctly incrassate medially; scape length 2–3, **sabuleti** subsp. **hamulata**
Antennal scapes subcylindrical 5
5. Size 5–6.3 mm ..... **brevinodis**
Size 6.3–7.2 mm ..... **brevinodis** subsp. **sulcinodoides**
6. Antennal scape length 3 7
Antennal scape length 4–7 11
7. Volsellae of genitalia without median tooth ..... **wheeleri**
Volsellae of genitalia toothed 8
8. Size 3.5–4 mm ..... **schencki** subsp. **tahoënsis**
Size 4.6–5.6 mm 9
9. Antennal scape length 3–4; scapes slightly bent medially, **brevinodis** subsp. **brevispinosa**
Antennal scape length 3 or less; scapes slightly bent at the base 10
10. Antennal scape length slightly less than 3; about 2½ times as long as broad; color brown ..... **sabuleti** subsp. **nearctica**
Antennal scape length 3; about 3 times as long as broad; color dark brown, **schencki** subsp. **emeryana**

11. Antennal scape length 6–7; scutum of mesonotum completely sculptured, partly obscuring Mayrian furrow . . . . . **scabrinodis** subsp. **mexicana**
    Antennal scape length 4–6; scutum of mesonotum largely smooth and shining, Mayrian furrow distinct 12
12. Antennal scape length 4–5, typically 4; scape ¼, or less, as broad as long . . . . . **sabuleti** subsp. **americana**
    Antennal scapes longer and more slender 13
13. Antennal scape length 5–6, typically 6; scape one-fifth or more, as broad as long . . . . . **lobicornis** subsp. **fracticornis**
    Antennal scape length 6; scape one-seventh as broad medially as long, **laevinodis** var. **bruesi**

The males of *schencki* subsp. *spatulata*, *brevinodis* subspp. *discontinua* and *kuschei* and of *M. laevinodis* varieties *neolaevinodis* and *champlaini* are unknown.

FIG. 1. Antennal scape of *Myrmica sabuleti americana* Weber, worker.
FIG. 2. Antennal scape of *Myrmica schencki emeryana* Forel, worker.
FIG. 3. Antennal scape of *Myrmica lobicornis fracticornis* Emery, worker.

THE HOLARCTIC SPECIES OF MYRMICA LATREILLE

Myrmica rubra (L.) Latreille

Myrmica rubra was described in the 10th edition of the Systema Naturae (1758, p. 983) as *Formica rubra:*

"F. testacea, oculis punctoque sub abdomine nigris."

In the 12th edition (1767) he adds:

"Habitat in Europa tuberibus graminosis; pessime nostratum pungit."

Latreille, in 1810, (Cons. Gen. Crust. Ins. 312 No. 445, 437) made *Formica rubra* the type of genus *Myrmica* and this genotype has been accepted by later myrmecologists.

In 1846 Nylander split *Myrmica rubra* into the species *laevinodis*, *ruginodis*, *sulcinodis* and *scabrinodis* but, unfortunately, did not retain the specific name of *rubra* for any ant. Emery pointed out, in 1908, that *Myrmica rubra* could only be applied to *laevinodis* and *ruginodis*, for they were the only species of *Myrmica* that could sting at all badly. He therefore made *laevinodis* and *ruginodis* subspecies of *rubra* but neglected to synonymize one of them with the typical *rubra*. The genotype, of course, must be represented by a concrete form.

The description "testacea, oculis punctoque sub abdomine nigris" fits *ruginodis* better than it does the paler *laevinodis*. Santschi (1931, p. 339) has also pointed out that, since *laevinodis* was the first species to be taken out of *rubra*, the remaining species, *ruginodis* of Nylander, becomes a synonym. I am here following Santschi in synonomyzing *ruginodis*.

Myrmica subsp. **rubra** (L.)

M. ruginodis, Nylander, Act. Soc. Sc. Fennicae, 1846, 2: 929–930, pl. 18, figs. 5, 30, ♥ ♀ ♂; Finzi, Boll. Soc. Adr. Sc. Nat., Trieste, 1926, 29: 85–86, fig. 2.
M. rubra ruginodis of authors in Genera Insectorum (Emery, 1922).
M. rubra (L.), Santschi, Rev. Suisse Zool., 1931, 38: 330.
M. dimidiata, Say, Boston Jour. Nat. Hist. 1836, 1: 293.[2]

Worker (after Nylander): Length 2 lin. Similar to the preceding (*M. laevinodis*), but a little larger, very coarsely rugose, metanotum longitudinally rugose in front of the spines, spines long and the pedicel with irregular longitudinal, but not profound, rugosities. Clypeus above rather smooth. Otherwise as in the preceding.

Female (after Nylander): Length almost 2½ lin.

Similar to the preceding female, but colored as follows and metathoracic spines distinctly double the length: Dorsal surface of head fuscous, clypeus darker eyes black; between the eyes, the mandibles and antennae, testaceo-ferruginous; mandibles at the apex a little fuscous. Clypeus rather more confusedly striate than in the preceding. Metanotum and sides of thorax faintly, scutellum very distinctly,

[2]*Myrmica dimidiata* Say from the United States was described as "body pale yellowish: thorax somewhat tinged with piceous" . . . "length over one-fifth of an inch;" the omitted part of the description deals with the wings and is a purely generic diagnosis. The color of the body is that of no nearctic *Myrmica* female although the size might be that of any of the forms of Eastern America. It is unsatisfactorily synonymized with the type species of the genus since the actual specimen appears to be lost and it is impossible otherwise to correlate it with known forms.

fuscous; spines very long. Wings as in the preceding. Legs entirely a pallid testaceo-ferruginous. Pedicel as in the worker.

Male (after Nylander): Length 2½ lin.

Very similar to the male of the preceding species, but a little larger, head in the first place conspicuously larger, stigma of the wings distinctly fuscous, legs long and bare. Head shining, finely and faintly rugulose; clypeus smooth and evenly convex. Wings as in the female; legs lightly pubescent, almost bare.

Figure 5 of Nylander's description is of the wing of a female. Figure 30 is of the epinotum and petiole in profile; the spines are drawn slightly deflected downward and only slightly shorter than the declivity ventral to them; the metasternal teeth are acute and directed upwards; the petiole, from apex of mid-ventral tooth to posterior margin, is distinctly longer than high and with concave anterior face and subcylindrical peduncle.

For a complete discussion of this subspecies, see Donisthorpe (1915, pp. 115–121). It is widely distributed in Europe and in western Asia.

Myrmica rubra var. **khamensis** Ruzsky

M. ruginodis Nyl. var. *khamensis*, Ruzsky, Ann. Mus. Zool. Acad. Imp. Sc., 1915, 20: 441, figs. 22–24, ♀.

Worker (after Ruzsky):

Differing from the typical form by the smooth and shining infraspinal surface of the epinotum, the basal surface also being flatter. The epinotal spines are shorter, the sculpturing of the body weaker and the color darker.

Type Locality: Tibet: Yangste basin, 11,400 feet, Aug. 1900, Sept. 1901 (Kozlov).

According to Ruzsky's figures the epinotal spines are distinctly shorter than the declivity ventral to them and have the apices directed upwards. The length of the petiole from apex of ventral tooth to postpetiole is a little shorter than the height at the node. The antennal scape distinctly exceeds the occipital margin and is relatively incrassate distally.

Myrmica rubra var. **kotokui** Forel

M. rubra subsp. *kotokui*, Forel, Sitz. der Bayerisch. Akad. Wiss., 1911: 267–268, ♀ ♀, ♂.

Worker (after Forel): Length 3.7–4.3 mm.

Related to *laevinodis* and *kurokii*, but much smaller than the latter and with weaker sculpturing. Head even longer than in *rugulosa*, much longer than wide, posteriorly somewhat narrower than in the middle. Antennae as in *laevinodis*, etc.; the bend of the scape some wider. Epinotal spines precisely as in *rubra*, much longer than in *laevinodis*. Petiole thicker than in *laevinodis*, somewhat as in *rubra*. Sculpturing of the head even weaker than in *laevinodis*, but the clypeus is quite wrinkled. Sculpturing of the thorax as in *rubra* (stronger than in *laevinodis*), but the epinotum between the spines is smooth. Color as in *rubra*, or somewhat darker and at the same time the reddish color somewhat paler.

Female (after Forel): Length 5.5 mm.

Head as in the worker, posteriorly clearly narrower than in the middle. Thorax narrower than the head. Epinotum smooth between the spines. Brown; joints, mandibles, antennae and legs yellowish to brownish yellow. Otherwise as in ***rubra***.

Male (after Forel): Length over 6 mm.

Head somewhat longer than broad, posteriorly not broader than anteriorly (in ***rubra*** broader than long, posteriorly broader than anteriorly). Almost black; gaster posteriorly brownish, with lighter sutures; legs reddish; antennal scape and femora brown. Otherwise as in ***rubra***.

Type Locality: Northern Japan (Dr. Haberer).

"Perhaps only a variety of ***rubra***, but differs in the shape of the head and the smooth surface between the epinotal spines."

The single worker mentioned by Dr. Wheeler (1928) from Nikko (Hondo) (2,000–3,000 feet) seems referable to this form. As Dr. Wheeler states "the petiole and post-petiole are finely punctate and on the sides coarsely rugose, but the upper surface is smoother and on the postpetiole with a few short sulci."

Myrmica rubra var. **orientalis** Karawajew

M. ruginodis subsp. ***orientalis***, Karawajew, Mem. Acad. Sc. Ukraine, 1926, 4: 47, fig. 1, ☿; Kuznetzov-Ugamskij, "The Ants of the South Ussuri Region (In Russian)," 1928: 37–39, figs. 22–26, ☿ ♀ ♂; Kuznetzov-Ugamskij, Zool. Anz., 1929, 83: 33, ☿ ♀ ♂.

Worker (after Karawajew and Kuznetzov-Ugamskij): Length 4–4.5 mm.

Head broadest anteriorly, anterior margin of the clypeus somewhat more angular than in the typical form, frontal carinae somewhat more diverging posteriorly; the antennal scape clearly surpasses the occipital margin (by a distance equal to more than its distal diameter, according to the figure). Epinotal spines longer than in the typical ***M. laevinodis***, metasternal spines different, pointed or blunt. Petiole angular in profile.

Sculpture as in the typical ***rubra*** except for the somewhat diverging longitudinal sculpturing on the head; infraspinal surface of epinotum smooth and strongly shining; dorsal surface of pedicel finely sculptured, dully shining.

Color dark brown, legs, antennae and apex of gaster somewhat lighter.

Female (after Kuznetzov-Ugamskij). Length 5.7 –6.2 mm.

Blackish brown. Mandibles yellowish brown. Sides of the head, thoracic sutures, pedicel, ventrally, and apex of gaster reddish brown.

Male (after Kuznetzov-Ugamskij). Length 4.3–5.6 mm.

Black or blackish brown. Antennae, mandibles and legs lighter or quite clearly brownish. Antennal scape equal in length to the 4 following segments together (according to Kuznetzov-Ugamskij's figure).

Type Locality: 30 km. north of Vladivostok. (W. Fedynsky). Siberia: Shore of Kosminschen Bay, Pestshanyi, Gulf of Amur, Okeanskaja, Tigrovaja, Bassargin, Sichoto-alin-Pasz between Kangarez and Ssutschan (Kuznetzov-Ugamskij).

Myrmica rubra var. **silvestrii** Wheeler

Myrmica ruginodis var. *silvestrii*, Wheeler, Boll. Lab. Zool. R. Ist. Portici, 1928, 21: 100–101, ♀.

Worker (Original description). Length 4.5–5.5 mm.

"Of the same size as *ruginodis* (*rubra*), but differing in the following characters: Head larger and broader; antennal scapes a little more slender at the base, epinotal spines straight and distinctly shorter, petiolar peduncle shorter and the node more sharply truncated above. Sculpture coarser, the rugae on the pronotum being thicker, more rounded and very irregular and vermiculate, the declivity of the epinotum smooth and shining. Petiole and postpetiole much more strongly longitudinally rugose, the latter subopaque. Color much darker; deep piceous brown; posterior portion of head, petiole, postpetiole and most of gaster nearly black; epinotal spines and legs brownish yellow; mandibles, antennae, ventral portion of petiole and tip of gaster somewhat darker and more reddish."

"Fifteen workers from Chuzenji Lake, near Nikko (Hondo) (type-locality), Japan, and one somewhat smaller specimen from Nikko."

"This variety is quite distinct from *kotokui* in its larger size, darker color, relatively shorter epinotal spines and more coarsely sculptured petiole and postpetiole."

Myrmica rubra subsp. **yoshiokai,** subsp. nov.

Worker: Length 4.5–5.3 mm.

Head, between the eyes, about 0.6 as broad as long (with mandibles); occipital corners evenly rounded, occipital margin straight; antennal scape slightly exceeding the occipital margin, obtusely and evenly bent at the base as in the typical *rubra*; joints 1 and 2 of the funiculus together as long as joints 3–5 together; antennal club 4-jointed. Thorax, in profile, deeply and angularly impressed at the mesepinotal suture; epinotal spines in profile, slender, acute, projected backwards and upwards at about 45 degrees, slightly shorter than the declivity ventral to them; from above, widely diverging, about 1½ times as long as the distance between their bases. Petiole, in profile, slightly shorter from apex of ventral tooth to postpetiole than it is high; anterior surface weakly concave, dorsal surface weakly convex; the two meet at a slightly rounded right angle. Postpetiole, in profile, with posteriorly produced convex dorsal surface, ventral surface produced in a slight concavity anteriorly. Gaster ovate. Legs moderately long and slender.

Surface of body shining. Dorsal surface of head finely and quite regularly rugulose, sides reticulate-rugulose, base of sculpturing feebly punctate; frontal area smooth but for several median striae; clypeus with a variable number of low rugae which fade out posteriorly, sparsely punctulate interrugally; general sculpturing somewhat stronger than in the typical *rubra*. Thorax and pedicel sculptured as in the typical *rubra*; declivous surface of epinotum smooth but for faint transverse striae between the spines which grow coarser towards the dorsal margin.

Pilosity as in the typical form.

Color of the body dark brown, appendages yellow brown, slightly darker than some Japanese specimens of the typical *rubra* and much darker than the majority of European specimens.

Described from three workers from Gummaken, Japan, 14. VII.30 (H. Yoshioka coll.) in Dr. Wheeler's collection.

This subspecies is distinguished from the typical ***rubra*** chiefly by the shorter antennal scape and petiole and by the deeper mesoepinotal notch. It is distinctly larger than the variety ***kotokui*** Forel and has the epinotum between the spines faintly striate. From ***kurokii*** Forel it is distinct in the absence of the medial occipital convexity, differently formed pedicel, less coarse sculpturing and in other ways. From ***rubra*** var. ***silvestri*** Wheeler it differs in distinctly narrower head, differently formed pedicel, much finer and more longitudinal sculpturing and in other ways.

Myrmica rubra var. **ruginodo-laevinodis** Forel

M. rubra race *ruginodo-laevinodis*, Forel, Den. Schw. Ges. NW., 1874, 26: 77–79, ♀ ♀.

A name for the transitions between ***rubra*** (***ruginodis***) and ***laevinodis***. Donisthorpe (1927, p. 123) gives the bibliography and discusses this form.

Myrmica laevinodis Nylander

M. laevinodis, Nylander, Act. Soc. Sc. Fennicae, 1846, 2: 927–928, pl. 18, figs. 4, 31, ♀ ♀ ♂.

Worker (after Nylander): Length 1¾–2 lin.

Very shining, dirty testaceous, eyes small, prominently rounded and black. No ocelli. Vertex and front of head a little darkened, entirely longitudinally subreticulate-striatulate, but less regularly laterally; striae from the margins to the occiput darkened; clypeus above and the frontal area smooth; mandibles about 8-dentate, apically smooth; margins of the frontal laminae suberect, a little reflexly arcuate. Antennal scapes bent basally in a small arc. Thorax narrower than the head, compressed between the meso- and metathorax, dorsally depressed; metanotum transversely rugulose in front of the spines. Pedicel almost smooth, shining, sparsely pilose. Gaster longer than the head, ovate, seen from above, a little broader than when seen from the side; dorsally sometimes less infuscated, nearly entirely fuscous; gaster marked either with little spots or large fuscous blotches, sometimes obsolete.

Female (after Nylander): Length 2½ lin.

Similar to the worker but larger, darker and more rugose. Ocelli distinct. Head fuscous, mandibles testaceous, at the apex slightly smooth, fuscous; antennae testaceous, at the apex fuscous. Mesothorax testaceo-ferruginous, otherwise ferrugineo-fuscous, epinotal spines much shortened, subdentiform. Legs entirely a sordid, pale testaceous, pubescent. Pedicel obsoletely rugulose. Gaster nearly longer and a little broader than the thorax, rather more rotund than in the worker, dorsally and medially fuscous. (Wings absent in our specimens).

Male (after Nylander): Length 2 lin.

Fuscous black, shining, head a little opaque. Head faintly and thinly striatulate to rugulose, small. Palpi and mandibles testaceous, about 7-denticulate, rufous at their apices. Antennae fuscous, funiculi

at least sordid rufous; scapes almost exceeding one-third of the funiculi, about as long as the 7 following joints; antennae 13-segmented. Eyes very prominent; ocelli distinct. Thorax very shining; almost all the sutures crenate; metathorax with subangular tubercles on both sides. Wings chiefly hyaline, from the stigma to the base a faint, pale cinereous, veins and stigma dilute, pale cinereous; . . . (wing venation), wings about 2¼ lin. long. Pedicel and gaster shining. Margins of the leg segments and the entire tarsi pale testaceous, tibiae sometimes pale fuscous; long, slender pilosity.

Figure 4 of Nylander's description is of the wing of a male in which the radial vein traverses the entire length of the first cubital cell, forming a second cubital of about half the size. Figure 31 is of the epinotum and petiole in profile; the spines are about half as long as the declivity ventral to them; the petiolar peduncle is subcylindrical and the node rises smoothly but at right angles, the node being about ¾ as high as the petiole is long between the apex of the ventral tooth and the posterior margin.

For a complete discussion of this subspecies see Donisthorpe (1915, pp. 110–114). It is widely distributed over Europe and Asia.

Myrmica laevinodis var. **bruesi** Wheeler

M. rubra laevinodis var. *bruesi*, Wheeler, Psyche, 1906, 13: 38.

Original Description: "A number of workers, females and males taken by Mr. C. T. Brues and myself during 1900 and 1902 from a few large colonies nesting under stones at the edge of Fay's Woods, Woods Hole, Mass., agree very closely with European specimens of *M. laevinodis* from Russia, Austria, Germany, England and Scotland in my collection. The thorax of the workers of the American form is smoother, more shining and less regularly sculptured than in the European specimens, but I am unable to find any other differences of importance and therefore establish this variety with some hesitation. I should be inclined to regard it as directly imported from Europe were it not that Forel has described two subspecies of *M. rubra* (*M. neolaevinodis* and *M. champlaini*) from New York and Canada respectively, both allied to the European *laevinodis* but with distinctive characters. The former has short antennae, with the tips of the scapes extending only a short distance beyond the posterior corners of the head, the latter has very short epinotal spines. It thus appears that America possesses indigenous forms closely related to *laevinodis*, just as it has long been known to possess numerous varieties of the other boreal and subboreal subspecies of *M. rubra*."

The above account and description gives the status of this ant at the present time. I find among the collections distinct polymorphism in the workers. Many workers are indistinguishable, furthermore, from typical *M. rubra rubra* and have the epinotal spines clearly longer than the distance between their bases, have the infraspinal surface transversely striate and are dark reddish-brown in color. Males taken with them have more abundant and more erect hairs on the tibiae than are found in *r. rubra*.

In 1908 (Journal Econ. Ent., 1: 337–339) Dr. Wheeler recorded this ant from the Forest Hills and Jamaica Plain region about Boston. In

1933–34 I found it very common locally in the Boston vicinity and took it also at Woods Hole. Generally it was taken in rather damp situations. One colony consisted of 1094 workers and several queens; another had eight queens. In 1940 I found it at Nahant, north of Boston on the Bay, and in 1946 again at Woods Hole. Dr. A. H. Sturtevant has had a long acquaintance with the species at Woods Hole and agrees with me in doubting its validity. Dr. Wheeler, of course, was fully aware of its provisional status. It is curious that in the approximately half century in which it should be known in Massachusetts it has not spread farther. Indeed in 1946 it was still to be found exactly where it was in 1900—at the edge of Fay's Woods (or Gardens), Woods Hole. Stray workers were taken on top of the stone wall and in the woods nearby, across from the schoolhouse on School Street. *Myrmica schencki emeryana*, a native ant, was seen here also but the nearest worker found in a casual search on one day was about 50 feet away from *laevinodis*. It would be interesting to determine what factors, including competition from native Myrmicas and other ants, prevent the extension of the range of *laevinodis*.

Myrmica laevinodis var. **champlaini** Forel

M. rubra laevinodis var. *champlaini*, Forel, Mitt. Naturh. Mus. Hamburg, 1901, 18: 80–81, ♀.

Worker (after Forel):

Very similar to the foregoing (*M. neolaevinodis*), the metanotum, however, has only two strongly triangular teeth, or, if one prefers, two very short spines, which are not longer than they are broad at their bases. The sculpturing on the head and thorax is denser and stronger, almost as in *ruginodis*. The declivity of the metanotum, however, is entirely smooth and shining, and the pedicel has, only on the sides a few longitudinal impressions. Reddish with brownish head and gaster. Petiole very short, its posterior surface, from the apex, is as long as the anterior declivity, the latter somewhat concave. Antennal scape as in *neolaevinodis*, or even somewhat shorter; the scape does not exceed the occipital margin.

"Quebec, Canada. On the border of a meadow path, near the harbor, collected by myself.

"Both these forms are closely related to *laevinodis*, but with American peculiarities. While in *neolaevinodis* the spines are at least as strong as in *laevinodis*, they are extraordinarily stunted in *champlaini*."

Myrmica laevinodis var. **europaea** Forel

M. rubra subsp. *champlainii* var. *europaea*, Forel, Rev. Suisse Zool., 1911, 19: 457, ♀.
M. laevinodis var. *europaea*, Finzi, Boll. Soc. Adriatica Sc. Nat. Trieste, 1926, 29: 84, ♀.

Worker (after Forel):

Spines dentiform as in the type of the subsp. (*champlainii*). Peduncle of the petiole more distinct but shorter than in *laevinodis*. Color of a pale *laevinodis*. Sculpture of *laevinodis*.

Type Locality: Norway: Bredheim, Nordfjord (Prell).

Myrmica laevinodis var. **minuta** Ruzsky

M. laevinodis var. *minuta*, Ruzsky, Formic. Imp. Rossici, 1905: 670, ♀.

Worker (after Ruzsky): Length 3.5–3.8 mm.

Differing from the typical *laevinodis* in its small stature and the form of the petiolar node, which, dorsally, is broader and flatter; this and the postpetiole are somewhat dull and more sharply sculptured. Eyes somewhat larger and more convex. Segments 2–5 of the antennal funiculi are quite as broad as long. Epinotal spines as in the typical form. Color somewhat darker (head and gaster dorsally dark brown). Somewhat thicker upright hairs on the body.

Type Locality: Pamir: Andermanyn Pass, 28.VI.95.

Myrmica laevinodis var. **neolaevinodis** Forel

M. rubra v. *neolaevinodis*, Forel, Mitt. Naturh. Mus. Hamburg, 1901, 18: 80, ♀.

Worker (after Forel): Length 4.3 mm.

Brown with reddish legs and red-brown antennae. The antennal scape is strongly bent as in *laevinodis* and somewhat shorter (extending past the occipital margin only a little). The medial funicular segments are quite as broad as long (somewhat longer than broad in *laevinodis*). Petiole considerably shorter, with scarcely concave (almost flat) anterior surface. The antennae, moreover, are somewhat shorter and thicker. The sculpture of the head and thorax is somewhat stronger. Otherwise as in *laevinodis*.

From New York, imported alive with Iris roots to the Plant Quarantine Station in Hamburg.

Myrmica laevinodis var. **tenuispina** Forel

M. rubra laevinodis tenuispina, Forel, Ann. Mus. Zool. St. Petersburg, 1904, 8: 374, ♀.

Worker (Cotype). Length 4.4 mm.

Head 0.6 as broad between the eyes as long (with mandibles), occipital corners and posterior margin evenly rounded, eyes about ¼ closer to the anterior clypeal margin than to the occipital margin; anterior clypeal margin distinctly convex; antennal scape exceeding the occipital margin by about twice its distal diameter, evenly bent at the basal ¼–⅕; joints 1 and 2 of the funiculus together about equal to joints 3–5 together, antennal club 4-jointed. Thorax, in profile, evenly convex to the shallow, broadly depressed, mesoëpinotal suture; epinotal spines slender, bluntly tipped, narrow at the base, projected backwards and upwards at about 40 degrees, a little shorter than the declivity ventral to them; from above, distinctly longer than the distance between their bases, moderately diverging. Petiole, in profile, a little longer from apex of ventral tooth to postpetiole, than it is high; peduncle with converging margins, node rising evenly and forming an anterior face of slight concavity which forms a rounded right angle with the weakly convex dorsal surface. Postpetiole, in profile, with distinctly convex dorsal, and weakly convex ventral, surfaces. Gaster sub-elliptical. Legs moderately long and slender.

Dorsal surface of head, including clypeus, longitudinally rugulose, sides reticulate-rugulose; frontal area distinct, rounded posteriorly, smooth and shining; base of sculpturing distinctly punctate. Thorax

shining, dorsal surface sparsely and longitudinally rugose-vermiculate, more rugose posteriorly, sides rugose, somewhat reduced in an anterodorsal area; infraspinal surface of epinotum transversely striate. Pedicel rugulose-punctate, more sparsely dorsally. Base of gaster striate, otherwise smooth and shining.

Hairs of body moderately abundant, comparatively fine and acute; of appendages more abundant, reclining, subappressed on the legs; antennal club with coarse, appressed pubescence.

Color yellowish brown (darker than in the typical *laevinodis*), dorsal surface of head and median dorsal surface of gaster darker brown.

Type Locality: Ferghana: Kugart R., 6,–8,000 feet, 5.VIII.1895 (Kirzinskiz); Eastern Buchara; Karategin, Kala-i-choit, 21.VII, Tabidara-zagyrdescht, 17.VI, Darvas, Tasch-Kurgan, 22.VIII.1897 (Kaznakov), Samarkand.

Myrmica smythiesi Forel

M. smythiesi, Forel, Rev. Suisse Zool., 1902, 10: 226–227, ☿.

Worker (Cotype): Length 4.4 mm. (Length 3.4–4.5 mm., Emery).

Occipital margin straight; corners evenly rounded; clypeus produced slightly over the base of the mandibles in about a 145 degree angle; diameter of eyes fully twice the diameter of the distal end of the antennal scape; scapes clearly exceeding the posterior margin of the head; seen from behind, in the form of a sigmoid curve bent more at the proximal portion, distal end about twice the diameter of the proximal end; antennal club 3–4 jointed, funicular joints 1–2 together distinctly longer than joints 3–5 together; joints 3–6 of funiculus about as broad as long. Thorax, in profile, convex to the shallow mesoepinotal impression; epinotal spines, in profile, produced backwards and upwards at about a 50 degree angle, rather slender and acute, distinctly shorter than the declivity ventral to them; from above, about as long as the distance between their bases, widely diverging. Petiole, in profile, distinctly pedunculate, anterior face smoothly concave and meeting the slightly convex dorsal surface at a rounded right angle, distinctly longer from apex of ventral tooth to postpetiole than high. Postpetiole, in profile, distinctly higher than the petiole, about as long as high, anterior margin convex, posterior margin nearly plane. Gaster ovate. Legs moderately long and slender.

Surface of head rather finely and regularly sculptured, clypeus with about 8 rugae between the frontal carinae, frontal area clearly indicated, smooth and shining except at the striate margins; dorsal area finely and regularly rugulose, sides similar but with a few reticulations. Dorsal surface of thorax irregularly reticulate-vermiculate, sides rugose, somewhat vermiculate anteriorly. Pedicel regularly and finely rugulose, except on the dorsal surface of the petiole, densely punctate on the petiole, less on the postpetiole. Gaster smooth and shining but for short, fine basal striations. Legs and antennae shining, finely striate-punctate.

Pilosity rather scanty, fine, moderately long, mostly truncate dorsally, subappressed on the appendages; antennal club pubescent.

Color of body dark brown, gaster blackish brown, lighter apically; appendages brown.

Type Localities: Himalayas, 7,–12,000 feet, Deoban, 8,500 feet (Smythies); North West Himalaya (Gamble).

Other Localities: East Turkestan, East Siberia, Altai, 2,500 m. (after Emery); Middle Ussuri, Sidemi (Forel).

The affinities of this species seem with *M. rugosa* and, to a lesser extent, with *M. rubra*. The genitalia of the male of the subsp. *dshungarica* is distinct from that of any other form examined.

Myrmica smythiesi var. **bactriana** Ruzsky

M. smythiesi var. *bactriana*, Ruzsky, Ann. Mus. Zool. Petrograd, 1915, 20: 438–439, figs. 16–18, ♀ ♂.

Worker (after Ruzsky): Length 4–4.5 mm.

Epinotal spines shorter than in the type of the species, straight and slightly blunted apically; petiole a little shorter.

Sculpturing of the body, especially on the sides, rougher and more like in *dshungarica*.

Color darker than in the type of the species, thorax red brown, head and upper part of gaster blackish brown.

Male (after Ruzsky): Length 5–5.2 mm.

Antennal scape much as in *M. laevinodis*, about equal to the 6 following joints together, very feebly bent at the base and almost straight, about ½ as long as the flagellum; antennal club 5-jointed. Epinotal declivity with blunt protuberances. Petiole, from above, rounded.

Surface of head nearly dull or a little shining, finely rugose, finely and densely punctate on the sides and back; clypeus smooth and shining. Thorax with longitudinal rugae but mostly more or less smooth; sides with rounded and shallow rugae. Petiole nearly smooth. Gaster smooth and shining.

Antennal scapes and legs with oblique hairs only.

Color blackish brown, tarsi and exposed parts of genitalia brownish. Wings with a brownish cast.

Type Locality: Tibet: Darendo, Upper part of Yangtse basin, August 8, 1900 (Kozlov).

Myrmica smythiesi subsp. **cachmiriensis** Forel

M. smythiesi subsp. *cachmiriensis*, Forel, Rev. Suisse Zool., 1904, 12: 23, ♀.

Worker (after Forel): Length 3.4–3.8 mm.

Differing from the typical species in its pedicel which has a very fine sculpture, almost dull, very finely reticulate-punctate; metanotum partly very finely wrinkled. The sculpturing of the head is a little more regularly wrinkled. Head and thorax subopaque. The spines are longer than their bases and, above all, much more slender. The peduncle of the petiole is longer, almost as long as the node, and is more abrupt anteriorly. The mesoëpinotal impression is very profound, again more than in the type of the species, and the mesonotum has a median transverse impression. The posterior margin of the head is also more transverse, with the occiptal angles well marked. Of a black ebony, varying to blackish brown, with the legs, antennae and margins of the mandibles brown.

Type Locality: Cachmir: Sind Valley, 2,286–2,438 m. (Wroughton).

Myrmica smythiesi cachmiriensis var. **lutescens** Forel

M. smythiesi cachmiriensis var. *lutescens*, Forel, Rev. Suisse Zool., 1904, 12: 23, ☿.

Worker (after Forel): Length 3.2–3.7 mm.

Entirely dull yellow. Sculpturing identical with *cachmiriensis*, but less close and more shining. Peduncle of the petiole longer than the node; the latter more rounded.

Cachmir (Smythies):

"I possessed this variety a long time but did not have enough to determine it.

"It seems to constitute, with the preceding, a single race, considerably distinct from *carbonaria* Forel and the var. *rupestris*."

Myrmica smythiesi subsp. **carbonaria** Forel

M. smythiesii v. *carbonaria*, Forel, Rev. Suisse Zool., 1902, 10: 227, ☿.

Worker (after Forel): Length 4 mm.

Color and pilosity of the var. *rupestris*; pilosity a little stronger. But the insect is more slender, the head narrower, the mesonotum more elevated (as in *rugosa*), the spines very slender, a little longer than the distance between their bases, strongly diverging, directed above and behind but more upright than in the typical species. The head, thorax and pedicel are entirely dull, densely and finely reticulate-punctate between the wrinkles.

"A single specimen from Pachmarhi (Schurr). I have perhaps wrongly attached this form, which has the appearance of a *Leptothorax*, to *M. smythiesii*. It is perhaps a separate species. The pedicel has exactly the form of that in *smythiesii*."

Myrmica smithiesi subsp. **dshungarica** Ruzsky

M. rugosa dshungarica, Ruzsky, Formic. Imp. Rossici, 1905: 661–662, ☿.
M. smythiesi dshungarica, Emery, Deutsch. Ent. Zeitschr., 1908: 169, ☿.

Worker: Length 4.3–5 mm. (3.5–4.5 mm., after Emery).

Clypeus produced anteriorly over the base of the mandibles in the form of a 100-degree evenly rounded angle; eyes rather small, less than twice in diameter the diameter of the distal end of the antennal scape; antennal scapes barely extending to the occipital margins; seen from above, in the form of a long drawn-out sigmoid curve, evenly bent at the basal ⅓, the basal diameter slightly over ½ the distal diameter; antennal club 4-jointed, joints 1–2 of funiculus equal in length to 3–5 together. Thorax in profile, slightly compressed, with distinct, though rounded and shallow, mesoepinotal impression; epinotal spines, in profile, projected backwards and upwards as a 40–45 degree angle, stout, triangular with acute, deflected apices, appreciably shorter than the declivity ventral to them, from above, shorter than the distance between their bases, diverging. Petiole, in profile, with distinctly concave anterior face meeting the nearly flat dorsal surface at a sharp right angle, about as long from apex of ventral tooth to postpetiole as it is high; postpetiole, in profile, as high as the petiole and higher than its length, dorsal surface convex, ventral surface feebly convex. Gaster ovate. Legs of moderate length.

Surface of head between the frontal carinae moderately rugose, reticulate-rugose laterally, frontal area and posterior part of clypeus conspicuously smooth and shining, clypeus strongly rugose. Dorsal surface of thorax irregularly reticulate, becoming more rugose posteriorly, sides rugose. Dorsal surface of petiole irregularly wrinkled, sides more regularly vermiculate-rugose; dorsal surface of postpetiole strongly punctate, mostly smooth or a little sculptured, sides vermiculate-rugose. Gaster smooth and shining. Antennae and legs shining.

Pilosity moderately abundant, fine, acute, sub-appressed on the legs and antennae; antennal club with appressed pubescence.

Color red-brown, head and gaster dark brown; pilosity yellow.

Female (Dealate): Length 5.8 mm.

Similar to the worker. The epinotal spines, however, are shorter, the sculpturing of the head coarser, the pilosity more abdundant and the color lighter. Scutum of the mesonotum anteriorly with an irregularly triangular, finely punctate, area from which extend posteriorly several regular rugae and laterally a series of coarse, irregular vermiculations; sides of thorax rugose; pronotum reticulate only anteriorly.

Male: Length 4.5–5.1 mm.

Clypeus produced in a rounded anterior margin over the mandibles; antennal scape equal in length to the following 5–6 segments together, slender, bent evenly at the basal ¼, slightly greater in diameter distally than proximally; antennal club 5-jointed. Epinotal declivity with two, low, inconspicuous gibbosities or none. Petiole as high as long, anterior face concave, dorsal part in the form of an evenly convex node, ventral surface slightly convex, ventral tooth practically absent. Postpetiole slightly higher than the petiole and than it is long, convex above and below. Gaster long-ovate. Legs moderately long and slender. Sagittae of genitalia with 24–26 serrations; volsellae as illustrated.

Surface of the head densely punctate, finely and irregularly vermiculate, with more or less regular longitudinal rugae between the frontal area and the anterior ocellus; frontal area clearly delimited, triangular with rounded posterior margins, finely punctate. Thorax shining, variably rugose-punctate. Pedicel finely punctate with a few marginal faint rugosities, a mid-dorsal area on the petiole and a larger dorsal area on the postpetiole smooth and shining. Gaster smooth and shining.

Pilosity moderately abundant, very fine and acute, subappressed fine hairs on the appendages; appressed pubescence on the antennal clubs.

Color black, appendages and apex of gaster dark brown. Pilosity pale yellow. Wings hyaline with a brownish cast, veins and stigma brown.

Type Locality: Tscunyetschi Region (Dshungaric Altai), altitude 2,000 meters, border of an alpine meadow. Taken by Tsapaschnikoff, March 29, 1902.

Other Localities: Turkestan: Karkara, Central Tian-Schan, 2,–2,600 mm.; Dshityoguz, S. of Tssykkul Lake, alt. 2,600 meters (N. N. Kuznetzov- Ugamskiji); Za-Tlijsk, Alatau Mts. (Dshenishke). Siberia: Issil-Kul (no collector).

Myrmica smythiesi subsp. **exigua** Ruzsky

M. smythiesi subsp. *exigua*, Ruzsky, Ann. Mus. Zool. Acad. Imp. Sc. Petrograd; 1915, 20: 440, figs. 19–20, ♀ ♂.

Worker (after Ruzsky):

Distinguished by shorter, thicker and wider epinotal spines. These are broad at the base, then narrow abruptly apically to slender, though blunted, apices.

Head a little shorter and wider than in *bactriana*; clypeus produced anteriorly in the form of a rounded angle; antennal scape shorter and thicker.

Male (after Ruzsky): Length 5 mm.

Thorax thinner than in *bactriana* and body generally smaller. Head and thorax dull and finely rugulose, otherwise as in *bactriana*.

Color brighter and dark brown. Wings with a darker cast.

Type Locality. Bar-Chu River, 12,000 feet, Yangtse basin, August 2, 3, 1900 (Kozlov).

Myrmica smythiesi var. **fortior** Forel

M. smythiesi var. *fortior*, Forel, Rev. Suisse Zool., 1904, 12: 22–23, ♀.

Worker (after Forel): Length 4.2–4.5 mm.

Sculpturing stronger and less close than in the typical species. Similarly shining. Spines longer, rather longer than in their interval. Mesoepinotal impression feebler, little accentuated. Petiole a little more truncate anteriorly. Postpetiole shining (Emery). Dull brown, thorax, antennae, mandibles and legs a dull yellowish brown.

Sind Valley, 1891 m., Cachmir (Wroughton); Deota, 914 m., North West Himalaya (Smythies); East Siberia (Museum of St. Petersburg).

"This variety passes through all the transitions to the typical form and, on the other hand, to the var. *debilior* Forel and *rugosa* Mayr."

Myrmica smythiesi subsp. **himalayana,** subsp. nov.

Worker: Length 4.4–4.6 mm.

Closely resembling the cotype of the typical form but differing distinctly in the following characters:

Occipital margin slightly, but distinctly, impressed medially, angles evenly rounded. Epinotal spines reduced to acutely pointed teeth; seen from above, shorter than the distance between their bases, moderately diverging.

Striae at the base of the gaster almost wanting, much less distinct than in the typical *smythiesi*.

Type Locality: India: Simla (Wroughton).

Described from three workers in Dr. W. M. Wheeler's collection.

The variety *bactriana* Ruzsky is described with short epinotal spines, which, however, are blunted apically but the sculpturing is rougher and the color is darker. A subspecies *exigua* Ruzsky is also described with shorter epinotal spines than in the typical species but the head is shorter and wider, the anterior clypeal border rounded, and the antennal scape shorter and thicker.

Myrmica smythiesi subsp. **hecate,** subsp. nov.

Worker: Length 5.2–5.7 mm.

Occipital margin of head slightly impressed medially; angles evenly rounded; anterior clypeal margin produced over the base of the mandibles in a rounded lobe of about 115 degrees; antennal scape exceeding the occipital margin by a distance equal to more than its distal diameter; joints 1 and 2 of the funiculus together slightly shorter than joints 3–5 together; club 4-jointed. Thorax, in profile, feebly concave to the broad and shallow mesoëpinotal impression; epinotal spines slender, acute, directed backwards and upwards at about 30 degrees, shorter than the declivity ventral to them; from above, about 1½ times as long as the space between the bases, feebly diverging. Petiole, in profile, longer, from apex of ventral tooth to postpetiole, than high, anterior declivity clearly concave and meeting the dorsal surface at a subangular right angle. Postpetiole, in profile, as high as long, dorsal surface convex, ventral surface nearly flat, ending anteriorly as an acute angle. Gaster subelliptical. Legs moderately long and slender.

Surface of head more coarsely sculptured than in the typical form, frontal are smooth and shining, median dorsal surface longitudinally rugulose, laterally becoming reticulate. Dorsal surface of thorax thinly and very irregularly sculptured, mostly vermiculate anteriorly and longitudinally rugulose posteriorly; sides irregularly rugulose, somewhat vermiculate anteriorly. Base of sculpturing of head and thorax mostly smooth and shining, few punctations. Sides of pedicel sparsely rugulose, densely punctate; dorsal surfaces with obscure rugulosities, densely punctate. Base of gaster with faint, sparse striae, otherwise smooth and shining. Antennal scapes sparsely and finely striate; legs microscopically striate-reticulate.

Pilosity of body moderately long, fine and acute; appendages with more numerous subappressed hairs; antennal club and tarsi with appressed pubescence.

Color dark blackish-brown, appendages dark brown.

Described from two workers with the Indian Museum labels "sweepings in grass and low herbage, Brunetti, Darjiling, 6,000 feet, 24.IX.08, No. 8607–19" and "Botanical gardens, Darjiling, 6,900 ft., 7.VIII.09, C. Paiva, No. 8609–19."

There are slight differences between these two Himalayan specimens but hardly sufficient to justify separate names.

In the length of the epinotal spines, sculpturing of the pedicel and color this subspecies resembles the subsp. *cachmiriensis* Forel. The sculpturing of the head, the occipital margin, the mesoëpinotal impression and the size are quite different.

Myrmica smythiesi var. **rupestris** Forel

M. smythiesii var. *rupestris*, Forel, Rev. Suisse Zool., 1902, 10: 227, ☿.

Worker (after Forel):

General habitus as in the typical form but black, with the sculpture stronger than in *rugosa*, the pedicel strongly sculptured, the scapes reticulate, the pubescence of the tibiae oblique, the petiole more elongate (much longer than broad); otherwise as in the type.

Type Locality: North West Himalaya: Ekra Peak, 9,500 feet (Smythies).

Myrmica rugosa Mayr

Myrmica rugosa, Mayr, Reise Novara, Formicid., 1865: 19, note, ♀.

Worker (Cotypes): Length 5–6 mm.

Head about 0.65 as broad between the eyes as long (with mandibles). Occipital margin of head straight; occipital corners broadly rounded. Clypeus produced over the base of the mandibles in an angulate lobe of about 130 degrees; eyes less than twice as large in diameter as the distal diameter of the antennal scapes; scapes exceeding the posterior margin of the head appreciably; seen from above, bent smoothly at the basal 1/5 and very slightly at the distal end, distal end twice as wide as at the base; antennal club 4-jointed. Thorax, in profile, irregularly convex, distinctly impressed at the mesoepinotal suture; epinotal spines, in profile, produced backwards and upwards at about a 55–65 degree angle, narrow, straight and acutely pointed, a little shorter than the declivity ventral to them; from above, about as long as the distance between their bases, diverging. Petiole, in profile, distinctly pedunculate; anterior face concave, meeting the slightly convex dorsal surface at a rounded right angle; about 1/5 longer from apex of ventral tooth to postpetiolar border than high. Postpetiole, in profile, about 1/5 higher than the petiole, slightly higher than long, dorsal margin distinctly, ventral margin slightly, convex. Gaster ovate. Legs moderately long and slender.

Surface of the head coarsely sculptured; frontal area triangular, smooth and shining; clypeus and median dorsal area coarsely rugose, sides rugose-reticulate. Entire dorsal surface of thorax coarsely reticulate-vermiculate, sides rugose, anteriorly somewhat vermiculate. Dorsal surface of petiole deeply vermiculate, sides vermiculate-punctate. Post-petiole coarsely vermiculate-punctate. Gaster smooth and shining. Legs and antennal scapes finely striate-punctate.

Pilosity moderately abundant and long, mostly obtuse dorsally; subappressed to appressed hairs on the legs and antennae, antennal club coarsely pubescent.

Color of body blackish brown, appendages dark brown; pilosity pale yellow.

Type Locality: Himalaya.

Males of this species have not been reported but, judging from the workers, the species seems closest to *M. smythiesi* and *M. rubra*.

Myrmica rugosa subsp. **arisana** Wheeler

M. rugosa var. *arisana*, Wheeler, Proc. New England Zool. Club, 1930, 11: 95, ♀.

Worker: Length 5.6–6 mm.

Clypeus but slightly produced over the base of the mandibles and with evenly convex anterior margin; diameter of eyes nearly twice that of the distal end of the antennal scape; scape extending beyond the occipital margin by a distance equal to slightly more than its distal diameter; seen from a posterior view, bent, at its basal 1/5, evenly inward at about 40 degrees, distal diameter about twice that of the proximal end; joints 1–2 of the funiculus together equal in length to joints 3–5 together, antennal club 4-jointed. Thorax, in profile, irregularly convex to the deep mesoepinotal suture; epinotal spines produced

backwards and upwards at a 45 degree angle, broad at the base, slender and exceptionally acute apically, longer than the declivity ventral to them; from above, feebly diverging, 1½ times as long as the distance between their bases. Petiole, in profile, comparatively small, anterior face feebly concave, meeting the dorsal, slightly convex, surface at a rounded obtuse angle, length from apex of ventral tooth to postpetiole equal to the maximum height. Postpetiole, in profile, distinctly higher than the petiole; produced, on the dorsal surface, backwards as a large convexity, and, ventrally, as a smaller, anterior convexity. Gaster ovate. Legs long and slender.

Surface of the head moderately sculptured and shining, clypeus with about 8 rugae between the frontal carinae, frontal area distinct, triangular, smooth but for feeble rugae, dorsal surface rugose, sides reticulate-rugose, base of sculpturing punctate. Dorsal surface of thorax coarsely and irregularly reticulate-vermiculate, sides rugose, anteriorly somewhat vermiculate. Dorsal surface of petiole densely punctate, sides thinly rugose; mid-dorsal area of postpetiole somewhat smooth, finely reticulate, remainder sulcate- or feebly rugose-punctate. Gaster smooth and shining. Antennae and legs finely striate.

Pilosity rather thin, hairs long, slender and acute, subappressed on the appendages; antennal club with appressed pubescence.

Color of body dark brown, appendages and apex of gaster yellowish brown.

Type Locality: Formosa: Arisan (R. Takahashi), April 24, 1928.

Six workers taken in 1932 by L. Gressitt from the type locality are a trifle smaller, darker and more shining but merely illustrate the customary variation in this genus.

Arisana is clearly distinct from the typical form in deeper meso-epinotal impression, longer epinotal spines and smoother sculpturing on the pedicel.

Myrmica rugosa var. **debilior** Forel

M. rugosa var. *debilior*, Forel, Rev. Suisse Zool., 1902, 10: 228, ♀.

Worker (Cotypes): Length 4.2–5 mm.

Clypeus produced over the base of the mandibles as a more or less angulate flattened lobe of about 130 degrees; antennal scapes clearly exceeding the posterior margin of the head; seen from a postero-dorsal view, in the form of a sigmoid curve with the basal ¼ evenly bent; distal end about twice the diameter of the basal end; antennal club 4-jointed. Thorax, in profile, evenly convex to the distinct, but shallow, mesoëpinotal suture; epinotal spines, in profile, projected backwards and upwards at a 40–45 degree angle, slender, acute, from about as long to distinctly longer than the declivity ventral to them; from above, over 1½ times the distance between their bases, widely diverging. Petiole, in profile, with a distinct subcylindrical peduncle and a convex node rising evenly from the dorsal surface, posterior part of pedicel slightly pedunculate; distinctly longer from apex of ventral tooth to ventral junction with postpetiole than high at the node. Postpetiole, in profile, distinctly higher than the petiolar node or than it is long, dorsal convex surface produced posteriorly, ventral surface produced anteriorly as an acute lobe. Gaster ovate. Legs moderately long and slender.

Surface moderately and regularly sculptured, clypeus sparsely rugose, shining; frontal area distinct, smooth and shining; head longitudinally rugose, somewhat reticulate-rugose on the sides; interrugal surfaces punctate. Dorsal surface of thorax sparsely and irregularly reticulate, smooth and shining between; sides irregularly and feebly sculptured, somewhat reticulate anteriorly, vermiculate medially and rugose posteriorly; with occasional punctations. Pedicel densely punctate with a few scattered rugae. Gaster smooth and shining. Legs and antennae shining, finely punctate-striate.

Pilosity sparse, hairs long, fine, acute or truncate, subappressed on the legs; appressed pubescence on the antennal clubs.

Color of body black, appendages dark brown.

Type Localities: Himalaya, Deota (Smythies); Darjiling, 3,–8,000 feet, Northern India (Wroughton); Mysore (Rothney): Kămáon (Schlagintweit).

The densely punctate pedicel and the dark color distinguish this variety from the other known forms.

Myrmica rugosa var. **kirgisica** Ruzsky

M. rugosa var. *kirgisica*, Ruzsky, Horae Soc. Ent. Rossicae, 1903, 36: 314.

Worker (after Forel and Emery):

Head broader and shorter than in the type, more weakly wrinkled. Mesonotum and epinotal spines shorter, almost as in the var. *debilior* Forel. Color as in the type, only antennae and tarsi lighter brown.

Type Locality: Astrakhan.

Forel, who saw the type specimen, believed it to be a form of *rubra s. lat.*, probably in the neighborhood of *r. rubra* and *sulcinodis*, rather than of *rugosa*. The status of this variety must await the discovery of males.

Dr. C. Menozzi had generously sent me the following descriptions of two new species from the Himalayas. The descriptions and comments are his.

Myrmica aimonis-sabaudiae Menozzi, n. sp.

Operaria: Obscure brunneo-rufa, gaster niger, mandibulae, antennae et pedis brunnei. Caput opacum, profunde straito-rugosum, genis et occipite confuse reticulatis; clypei longitudinaliter striato, antice in lobum subacutum producto; mandibulis striatis, 8–10 dentatis; antennarum scapo basi curvato; flagellum clava 4-articulata. Thorax lateribus et mesonoto longitudinaliter rugosis; pronoto transversim rugoso, epinoti basi subtiliter striati, superficie declivi nitida, spinis gracilibus longissimis, suberectis; sutura promesonotali obsoleta, mesoepinotali impressa. Segmentum pediculi primum breviter petiolatum, nodo supra rotundato, secundum pyriforme, vel subconicum, latius quam longius, ancbo subtiliter punctato-striati. Pedes breviter oblique pilosi.

Long. mm. 5–5.5.

Habitat.—Karakorum (Himalaya).

Pour la constriction mésoépinotale trés marqué cette nouvelle

Myrmica se rattache au groupe de *M. smythiesi* For. Est trés semblable à *M. rugosa* Mayr mais avec le pétiole présque sessile et les articles 2–7 du funicule bien plus courts. Differé de *M. smythiesi* par les épines plus longues et par la sculpture.

Myrmica dicaporiaccoi Menozzi, n. sp.

Operaria: Nigra, antennis, pedibus et gastri articulis postremis brunneo-rufescentibus, genibus, coxis et collo luteolis. Caput rugoso-striatum, spatiis inter rugas et strias punctulatis; dorsum et latera promesonoti rugosa; epinotum et pediculum punctulatis, gaster laevis et lucidus. Mandibulae vix striatae. Clypeus in *M. rugosa* Mayr elongatus, sed ossovius striatus et opacus. Scapus marginem occipitalem superans; primus et secundus funiculi articuli subaequales, 3–8 paulo longiores quam latiores; clava tribus articulis sistens. Oculi fortiter convexi et valde prominentis. Thorax sutura meso-epinotali vix conspicua, neso-pronotali obsoleta. Epinotum parte basalis quam declivi longiore, spinis brevibus apice vix incurvatis. Petiolum breviter pedunculatum, nodo parvo; postpetiolum antice et postice aeque angustatum.

Long. mm. 4.

Habitat.—Karakorum (Himalaya).

Du groupe *M. rugosa* Mayr; se distinque facilement par la sculpture, les épines courtes mais surtout par les yeux petits, assez couvexes et beaucoup sailliants en dehors des cotés de la tete.

Myrmica tibetana Mayr

M. tibetana, Mayr, Hor. Soc. Ent. Rossicae, 1890, 24: 279, ☿; Emery, Deutsch. Ent. Zeitschr., 1908: 181-182, fig. 13, ☿; Ruzsky, Ann. Mus. Zool. Acad. Sc. Petrograd, 1915, 20: 440–1, fig. 21, ☿ ♂.

Worker (after Mayr and Emery): Length 3.2–3.5 mm.

Noteworthy for the compact habitus. Form of the head about as in *rubra*, except that the antennae are shorter, the segments before the 4-jointed club are as broad, or somewhat broader, than long. Thorax short and high, mesoëpinotal impression strong; epinotal spines very short and broad at their bases, a little diverging. Petiole short and thick, with slightly concave anterior face. Postpetiole as broad as long.

Sculpturing of the head as in *laevinodis*; of the thorax, very fine, the surface dull or weakly shining, reticulate to reticulate-rugose; of the pedicel shining, slightly reticulate laterally, above smooth.

Pilosity much as in *laevinodis* but the erect hairs shorter; legs and antennae with copious, oblique and subappressed hairs, here and there with appressed pubescence.

Color light reddish brown, head and gaster brown.

Male (after Ruzsky): Length 4–4.9 mm.

According to Ruzsky's figure the antennal scape is subcylindrical, somewhat narrowed and a trifle bent at the base and is equal to the following 4–5 segments together. The antennal club is 5-jointed.

Type Locality: North Tibet: Jumel-Kuku Mt., April–June, 1884.

Myrmica tibetana subsp. **chinensis** Viehmeyer

M. chinensis, Viehmeyer, Archiv. f. Naturg., 1922, 88: 204, ♀ ♂.

Female (after Viehmeyer): Length 5 mm.

Distinguished from *tibetana* Mayr by the short, at the base gently curved, scape of the antenna and by the smooth part of the pedicel. Head somewhat shorter than in the worker of *tibetana*, the occipital margin a little more rounded, sides more even than in *laevinodis*, antennal scape not quite reaching the occipital margin (in the *tibetana* worker it surpasses by a trifle). Epinotal spines at least as long and quite similar to *laevinodis*, the space between them smooth and shining. Petiole, in profile, very sharply angular, postpetiole clearly transverse. Blackish brown to black, the legs more or less brown, the wings somewhat strongly smoky. Upright hairs yellowish, shorter than in *laevinodis*. Sculpturing very similar to that in *laevinodis*, barely weaker; eyes, however, less projecting and the petiole more or less sculptured.

Male (after Viehmeyer): Length 3.5 mm.

Head dull, extremely finely reticulate, the upper surface of the mandibles longitudinally rugose. Antennal scape exceeding the occipital margin a good deal, at the base weakly bent, the club clearly 5-jointed, differing from Ruzsky's illustration of the *tibetana* ♂ in being more slender. Epinotal angles sharper than in *laevinodis*, but without teeth. Thorax finely and longitudinally rugulose, but shining; the remainder of the body strongly shining. Only the legs with shorter, appressed pubescence. Color black, legs brownish black, wings as in the female.

Type Locality: China: Szechwan Province: Sungpanting (Stötzner Expedition of 1914).

"Perhaps only a form of *tibetana* and near its variety *furva* Ruzsky."

Myrmica tibetana var. **furva** Ruzsky

M. tibetana var. *furva*, Ruzsky, Ann. Mus. Zool. Acad. Imp. Sc. Petrograd, 1915, 20: 440–441, ♀.

Worker (after Ruzsky):

Differs from the typical form in deeper sculpture and darker color.

Type Locality: Tibet: Yangtse River region, 12,–12,500 feet, March, May, 1901 (Kozlov).

Myrmica commarginata Ruzsky

M. commarginata, Ruzsky, Formic. Imp. Rossici, 1905: 708–709, ♀.

Worker (after Ruzsky and Emery): Length 3.7 mm.

Dark reddish brown, antennae and legs lighter, head and gaster dorsally blackish brown. Head and thorax dull, coarsely wrinkled; declivous surface of epinotum between the spines smooth; nodes of the pedicel somewhat shining and finely wrinkled; gaster smooth. Head long with rounded occipital margin; eyes situated a little before the middle of the sides of the head; frontal area smooth; mandibles longitudinally striate, with 6 teeth; scape at the base bent in a curve, funiculus with 4-jointed club. Mesoepinotal impression small, not deep. The mesoepinotal region strongly compressed and, on either side, dorsally

with a carina which extends from the pronotum to the base of the spines. Epinotal spines not longer than half the basal surface (declivity ventral to them), diverging and broad at the base and somewhat laterally compressed, the apices somewhat curved. Petiole short, anterior face forming an angle with the dorsal, very weakly convex, surface, without a cylindrical peduncle. Postpetiole somewhat higher than the petiole, broader and of similar form. Upright hairs somewhat thick on the head and gaster, thinner on the thorax and pedicel, legs shining, with sparse, thin, reclining hairs.

Type Locality: Transbaikal: Tabajkal region, 27.VII.1901.

"This species is very distinct in the lateral carinae and narrowness of the thorax."

Myrmica inezae Forel

M. inezae, Forel, Rev. Suisse Zool., 1902, 10: 226, ♀.

Worker (after Forel): Length 5.2 mm.

Black. Legs, antennae, mandibles and apex of gaster russet-brown. Pilosity moderately erect, yellowish red, oblique, short and very abundant on the tibiae and scapes. Gaster, frontal area and epinotal declivity smooth. Legs and scapes reticulate and subopaque, the scapes also wrinkled. All the rest (including the mandibles) grossly wrinkled, rough between the wrinkles, the pedicel more feebly sculptured. The ridges are longitudinal on the head, *transverse* on the pronotum, the mesonotum and between the spines, irregular on the margins and on the metanotum. Mesoëpinotal impression feeble. Epinotal spines subvertical, inclined backwards, a little longer than in *M. rugosa* (where they are subhorizontal), almost as long as the basal face. The petiole with a long, slender pedicel, much longer than the node, which is more subcubic, broader at the summit than in *rugosa* (less cuneiform). Postpetiole as in *rugosa*. Otherwise as in *rugosa*. Not the metasternal spines.

"A single worker from Pachmarhi (Schurr). Much different from *ritae* and *margaritae*, which have the metasternal and epinotal spines much longer; this species is distinguished from *rugosa* by the petiole, the transverse wrinkling and its subvertical spines."

Myrmica pachei Forel

M. pachei, Forel, Bull. Soc. Vaud. Sc. Nat., 1906, 42: 79–82, ♀ ♀ ♂.

Worker (Cotype): Length 5–5.5 mm. (after Forel).

Head, between the eyes, 0.6 as broad as long (with mandibles), anterior clypeal margin convex, eyes, in breadth, twice the diameter of the distal end of the antennal scape; scapes surpassing the posterior margin of head by ⅕ their length, seen from behind, in a drawn-out sigmoid curve, bent at basal ¼ and close to distal end, proximal diameter ½ that of distal end; antennal club 4-jointed, joints 1–2 of the funiculus together as long as joints 3–5 together. Thorax, in profile, unusually convex to the moderately impressed mesoëpinotal impression; epinotal spines slender, straight, projected backwards and upwards at slightly less than 40 degrees, slightly shorter than the declivity ventral to

them; from above, diverging, over 1½ times as long as the distance between their bases. Petiole, in profile, stout, anterior face slightly concave, dorsal surface evenly convex, distinctly longer from apex of ventral tooth to postpetiole than high. Postpetiole, in profile, distinctly higher than the petiole or than it is long, dorsal surface highly convex, ventral surface nearly plane, produced anteriorly in an acute small lobe. Gaster ovate. Legs moderately long and slender.

Surface of head shining, finely and evenly rugulose, densely punctate between; mandibles rugulose; clypeus shining, sparsely rugulose, punctate; frontal area smooth and shining. Dorsal surface of thorax *transversely* and densely rugulose, lateral surfaces rugulose, longitudinally basally, more vertical dorsally, anterior part thickly punctate. Pedicel finely reticulate-punctate with a few marginal, scattered and feeble rugae. Gaster smooth and shining. Legs and antennae finely striate.

Pilosity sparse, fine and acute; subappressed hairs on the appendages; antennal club pubescent.

Color dark brown, appendages hardly lightly, gaster piceous.

Female (after Forel): Length 5.6–5.8 mm.

Thorax narrower than the head. Longitudinal striae on the mesonotum; epistome more rugose. Wings brown, with the cubital cell divided into thirds by the intersection of a vein, as in the other species of the genus. Otherwise as in the worker, and hardly larger.

Male (after Forel): Length 5–5.7 mm.

Mandibles triangular, feebly sculptured, armed with about 6 teeth. Head slightly trapeziform, larger posteriorly than anteriorly, at the posterior margin slightly, and at the other margins more strongly, convex. Eyes nearly at the anterior third. The scapes, bent towards their base, surpassing the occiput by about ⅕ of their length. Second joint of the funicle distinctly longer than the first and the third. The metanotum armed with two triangular teeth. Petiole very convex dorsally, as long as broad.

Epistome transversely striate only on its anterior ⅔, smooth and convex behind. Frontal area smooth. Head striate as in the worker, but more strongly reticulate and dull to nearly dull. The striae in the middle of the front are compact, converging to a point, the extremity of the frontal area, and describing an elliptically convex bend about the frontal groove. They run from the front of the margin to the frontal area and diverge simply anteriorly. The head is sprinkled with punctations at the base of the striae. Sculpture of the thorax as in the female, but feebler. Posterior half of the metanotum smooth. Pedicel subopaque, finely reticulate, likewise the legs and scapes.

Color, pilosity and wings as in the female, but the teeth of the metanotum are black and the legs almost black. Wings less brown (more clear).

Type Locality: N. E. Nepal: Tersam, 3,600 meters (Pachei); from a colony in a tree trunk.

The fine sculpturing and especially the transversely and finely rugulose sculpturing of the thorax distinguish this *Myrmica* from all other known species.

Myrmica kurokii Forel

M. rubra v. *kurokii*, Forel, Mitt. Naturh. Mus. Hamburg, 1907, 24: 18, ♀.

Worker (after Forel): Length 5–5.2 mm.

Mandibles striate, with more or less curved, nearly even, outer border and 7 teeth. Clypeus strongly curved anteriorly as in the European *rubra*, but less than in *M. rugosa* Mayr. Frontal area smooth. Base of the scape somewhat roughly bowed as in *ruginodis* Nyl., but not as roughly as in *sulcinodis*; club 4-jointed (Emery). Head right-angled, with very clear, but only slightly indicated median impression. Scape exceeding the occipital margin a little. Thorax similar to that of *ruginodis* and especially similar to the form which Ruzsky has called *rugosa* var. *kirgisica*, and which by no means belongs to *rugosa*, but to *rubra*, in the neighborhood of *ruginodis* and *sulcinodis*, however, the mesoëpinotal impression is shallower and broader. The petiole is very short, not as short and thick as in *brevinodis* Emery, but, however, cuboidal, with a rounded, broad upper surface and not a blunt edge as in *kirgisica*. Postpetiole flatter than in *sulcinodis* (Emery). The spines are also much longer than in *kirgisica*, somewhat as in *sulcinodis* and somewhat deflected. 3–6 funicular segments somewhat broader than long.

Somewhat less coarsely rugose longitudinally than in *kirgisica* and *sulcinodis*, but coarser than in *ruginodis*. Metanotum smooth between the spines. Pedicel coarsely rugose. Abdomen smooth (short and finely striate at the base—Emery). Uneven between the rugosities, therefore little shining. Legs and antennal scape only with thick, somewhat fine, appressed hairs. Body with scattered yellow upright hairs.

Head and gaster brown, the latter dark brown; the remainder reddish brown.

"Differing from *kirgisica* in the petiole and the much more strongly curved clypeus. Through the much longer spines and the broader, even occipital margin, likewise clearly differentiated from the other subspecies."

Type Locality: Japan (ex. coll. Frühstorfer).

Three workers from the Southern Japanese Alps (H. Yoshioka coll.) appear referrable to this species although larger (5.3–6.1 mm.) and with the frontal area distinctly, though finely, striate. The head is about 0.67 as broad between the eyes as long (with mandibles). This is a very distinct species.

Myrmica kurokii subsp. **helleri** Viehmeyer

M. helleri, Viehmeyer, Arch. f. Naturg., 1922, 88: 204–205, ♀.

Worker (after Viehmeyer): Length 5.5 mm.

"Nearest to *M. kurokii* Forel of Japan; differing clearly from it, however, in the essentially stronger sculpturing."

Blackish brown, the legs a little lighter. Anterior part of the body, including the frontal area and the declivous surface between the epinotal spines, dull. Head somewhat coarsely and longitudinally, thorax con-

fusedly, pedicel, especially the postpetiole, somewhat finely, rugose; interrugally with extremely fine reticulations, laterally and posteriorly on the head, between the rugosities, with shallow pits. Head somewhat broader and shorter than in ***kurokii***, with even sides and the occipital corners more distinct than in ***sulcinodis***. Antennal scape as in ***rubra***, at the base broadly and weakly bowed; club 4-jointed, the anterior ("vorderen") joints somewhat shorter than in ***kurokii***. The pedicel similar in profile, but the weakly concave anterior surface of the petiole is somewhat longer and the dorsal surface slopes more strongly away from the angle. Postpetiole more weakly trans-verse. Otherwise entirely as in ***kurokii***. "Perhaps only a form of it."

Type Locality: China: Szechwan Province: Kwansien (Stötzner Expedition of 1914).

Myrmica kurokii subsp. **sontica** Santschi

M. kurokii* v. *sontica, Santschi, Bull. Ann. Soc. Ent. Belg., 1937, 77: 367, ☿.

Worker (after Santschi): Length 5–5.5 mm.

More elongated petiole than in ***kurokii***; basal face of epinotum between the spines reticulate in the large and medium individuals, more feebly and more longitudinally sculptured in the small; petiole reticulate-punctate, postpetiole more shining, with the ridges elongate; gaster shining with short basal striae; dark brown, sides and sterna paler, appendages russet and brighter.

Type Locality: Japan: Yamakita (C. Teranishi).

Myrmica kurokii subsp. **tipuna** Santschi

M. kurokii* st. *tipuna, Santschi, Bull. Ann. Soc. Ent. Belg., 1937, 77: 367–368, ☿.

Worker (after Santschi): Length not given but presumably as in *sontica*.

Distinguished from *sontica* chiefly by the more feeble sculpture of the pedicel and the more "claire" color of the abdomen. Mandibles 7–8–toothed, apical very long, striate; scape bowed and slender as in ***rubra***; eyes and antennae also as in ***rubra***; epinotal spines fine, as long as the interval between their apices but a little shorter than in ***rubra***; the petiole as in ***rubra*** or a little larger, the anterior pedicel longer as in ***kurokii***. Evidently a form based chiefly on sculpture and color.

Type Locality: Formosa (K. Sato).

Myrmica kozlovi Ruzsky

M. kozlovi, Ruzsky, Ann. Mus. Zool. Acad. Imp. Sc. Petrograd, 1915: 435–436, figs. 10–11, ☿.

Worker (after Ruzsky): Length 5–6 mm.

Head short, rounded posteriorly, clypeus convex, anterior margin rounded, frontal carinae small; antennal scape extending to the thorax, bent evenly at the base, antennal funiculus 4-jointed. Promesonotum feebly convex, metanotum flat dorsally, mesoëpinotal impression feeble; epinotal spines well developed, broad at the base, produced backwards, feebly divergent, with the apices sometimes a little deflected. Pedicel short as in ***M. sulcinodis***; petiole much shortened and with a short,

thick peduncle, anterior face feebly concave, dorsal and posterior surfaces convex. Postpetiole dorsally convex, ventral surface nearly plane.

Sculpturing of the body rough and rugose as in *M. rugosa*; clypeus with irregular rugae, smooth and shining interrugally and at the posterior margin adjacent to the smooth and shining frontal area; head dorsally with longitudinal rugae, laterally irregularly rugose and punctate. Thorax rugae, laterally irregularly rugose and punctate. Thorax coarsely and irregularly sculptured, punctate; only on the sides posterior to the prothorax is the sculpturing longitudinally rugose; bases of epinotal spines with fine longitudinal rugae. Pedicel less sculptured than the thorax, petiole with larger and more irregular rugae than the postpetiole, which is sulcate dorsally. Head, thorax and pedicel entirely dull, gaster smooth and shining with fine striae.

Gaster covered with yellowish hairs, legs with dense reddish hairs.

Color of body brownish black to black, legs, antennae and mandibles brown, tarsi lighter.

Type Locality: Eastern Tibet: Basin of the Yangtse River, 12,500–13,000 feet (Kozlov), March and May, 1901.

"This is a mountainous form between *M. rugosa* Mayr, *M. sulcinodis* Nyl. and *M. kurokii* Forel."

Myrmica kozlovi subsp. **mekongi** Ruzsky

M. kozlovi subsp. *mekongi*, Ruzsky, Ann. Mus. Zool. Acad. Imp. Sc. Petrograd, 1915, 20: 437, fig. 12, ♀.

Worker (after Ruzsky):

Differing from the typical form in shorter and more erect epinotal spines, feebler sculpture and lighter coloration.

Type Locality: Tibet: Bar-chu River, Mekong basin, 12,000 feet, Sept. 1900 (Kozlov).

Myrmica kozlovi subsp. **ruzskyi** nomen novum

M. kozlovi subsp. *subalpina*, Ruzsky, Ann. Mus. Zool. Acad. Imp. Sc. Petrograd, 1915, 20: 438, fig. 14, ♀.
(nec *M. rubra brevinodis* var. *subalpina* Wheeler, Bull. Wisconsin Nat. Hist. Soc., 1907, 5: 77, ♀.)

Worker (after Ruzsky):

Distinguished by the stout epinotal spines which are wide at the base, sharply curved in the middle and projected almost horizontally back; from above subparallel. These are longer than in *mekongi*.

Rugosity of head and thorax as in *subbrevispinosa*, color darker, otherwise much as in the above mentioned subspecies.

Type Locality: Eastern Tibet: Valley of the Yangtse, March, 1901 (Kozlov).

Ruzsky believed that this ant had such unique epinotal spines as to rank possibly as a distinct species. While Ruzsky labels his original figure as "*Myrm. kozlovi subbrevispinosa*, var. *subalpina*," and Emery followed him in the Genera Insectorum, his original description is headed "*Myrm. kozlovi*, subsp. *subalpina* subsp. nova."

Myrmica kozlovi subsp. **subbrevispinosa** Ruzsky

M. kozlovi subsp. *subbrevispinosa*, Ruzsky, Ann. Mus. Zool. Acad. Imp. Sc. Petrograd, 1915, 20: 437, fig. 12, ☿.

Worker (after Ruzsky): Length 5 mm.

Differs from the typical form and from *mekongi* in the form of the epinotal spines. These are short, thickened, and directed almost straight backwards.

Type Locality: Tibet: Yangtse Basin, March, 1901, (Kozlov).

Myrmica bergi Ruzsky

M. bergi Ruszky, Zool. Jahrb. Syst., 1902, 17: 473, ☿; Ruzsky, Formic. Imp. Rossici, 1905: 675–678, figs. 167, 168, ☿ ♀ ♂; Kuznetzov-Ugamskij, Zool. Anz., 1929, 83: 44–45, map.

Worker (Cotype): Length 4.6 mm. (4.5–5.5 mm., after Ruzsky).

Head 0.64 as broad between the eyes as long (with mandibles), occipital margin straight, occipital corners evenly rounded, eyes slightly closer to the anterior clypeal than to the occipital margin; anterior clypeal margin transverse. Antennal scape slightly exceeding the occipital margin, seen from a posterior view, bent at about the basal 1/5 in a rounded angle of about 30 degrees; joints 1 and 2 of the funiculus together about as long as joints 3–5 together, all joints longer than broad, club 4-jointed. Thorax, in profile, very evenly convex to the feeble and broad mesoepinotal impression; epinotal spines acutely pointed, straight, projected backwards and upwards at about 45 degrees, shorter than the declivity ventral to them; spines, from above, a little longer than the distance between their bases, slightly diverging. Petiole, in profile, short, peduncular margins converging anteriorly, anterior face slightly concave, a little shorter, from apex of ventral tooth to postpetiole, than it is high. Postpetiole, in profile, distinctly higher than the petiole and than it is long, dorsal margin convex and produced posteriorly, ventral margin convex and produced anteriorly. Gaster sub-elliptical. Legs of moderate length.

Surface of head shallowly sculptured; median dorsal surface, including clypeus, finely and closely rugulose, sides rugulose-reticulate, densely and conspicuously punctate between the sculpturing, frontal area clearly indicated, striate at the posterior margins, smooth and shining anteriorly. Dorsal surface of thorax irregularly sculptured with a general longitudinally rugose tendency, mesonotum with several nearly smooth areas, infraspinal surface of epinotum with fine transverse striae; sides of thorax longitudinally rugose; interrugal surfaces densely punctate, especially on the sides. Petiole rugose-punctate; postpetiole more shallowly rugose-punctate with a finely striate-punctate longitudinal area on the dorsal surface. Thorax smooth and shining. Antennal scapes finely striate; legs shining, indistinctly sculptured.

Pilosity moderately sparse, hairs of body, including those of dorsal thoracic surface, acute and moderately fine; moderately abundant and reclining on the appendages; antennal club with appressed pubescence.

Color of body reddish brown, slightly darker dorsally and with gaster dark brown; appendages reddish brown.

Female (after Ruzsky and Emery): Length 5.5–6.5 mm.

Color, sculpturing and pilosity about as in the worker; epinotal spines broad at the base, almost straight, pointed.

Male (after Ruzsky and Emery): Length 5 mm.

Clypeus and frontal area shining; head and thorax dorsally wrinkled; nodes of the pedicel shining. Scape about as long as ⅓ the funiculus or a little shorter than the 4 following joints; club 4-jointed. Epinotum with rounded gibbosities. Posterior femora not clearly incrassate in the middle. Pilosity of the tibiae about as in *sulcinodis*. Castaneous brown, darker dorsally. Wings dark.

Type Localities: Turkestan: Tas-Bulak, west coast of the Aral Sea; mouth of the Syr-Daja; Ack-Dshalpas, north shore of the Aral Sea (H. L. S. Berg, 1900–1).

Turkestan: Gschimkent (Cimkent), South Kazakstan, Kirgisen Steppe, Turkmenistan (N. N. Kuznetzov-Ugamskij).

Transcaucasia.

Ruzsky and Emery placed this species next to *sulcinodis* Nylander because of the form of the worker antennal scape. The short antennal scapes of the male and the short epinotal spines and fineness of sculpturing of the worker, however, lead me to believe its affinities are more with *M. brevinodis* Emery. Genitalic slides of the males would quickly settle this point.

Kuznetzov-Ugamskij (1929) gives a map showing the geographical distribution of this species. It is found in large, but isolated, areas between the Caspian Sea and Lake Balkash.

Myrmica bergi var. **barchanica** Ruzsky

M. bergi var. *barchanica*, Ruzsky, Formic. Imp. Rossici, 1905: 678, ♀.

Worker (after Ruzsky): Length 4.5–5.2 mm.

Sides of the head with stronger and thicker reticulations. Almost without upright hairs (there are, however, only isolated upright hairs on the anterior dorsal surface of the thorax, on the petiole and on the base of the gaster); on the head are groups of very thin and short hairs; the antennal scape almost lacks hairs. The wrinkles on the thorax are fewer, more or less regular. Sculpturing of the petiole is weaker. Color lighter than in *bergi*, similar to *stangeana*. Legs lighter than the thorax, yellow reddish-brown. Base of the gaster lighter than the other parts.

Type Locality: Astrakhan: Khauskaja Stavka (early June, 1902) (Ruzsky).

"Living in the midst of a rather luxuriant flora (mainly Linden trees and others). Nests in holes in the ground. I took it also on plants."

Myrmica bergi var. **divergens Karawajew**

M. bergi var. *divergens*, Karawajew, Zool. Anz., 1931, 94: 105, fig. 1, ♀.

Worker (after Karawajew): Length 4.5 mm.

Differs from the typical form as follows: The rugosities from the margins of the frontal area diverge in parallel and straight lines to the (occipital) angles (in the typical form they diverge in a fan-shaped area to the outer corners). The anterior margins of the frontal carinae are clearly rounded (in the typical form—I compare with an example at hand from Tshimkent, Turkmenistan, N. Kuznetzov, 18.VII.23—they

are more pointed). Anterior face of the petiole sloping evenly; in the above mentioned example it forms a weak concavity. In other respects similar to the typical form.

Type Locality: Insel Char-jalach, 50 km. below Olekminsk, 11.6.1925 (L. Bianchi).

This variety was described from one specimen.

Myrmica bergi subsp. **persiana**, nomen novum

M. bergi var. *fortior*, Crawley, Ent. Record, 1920, 32: 163, ♀.
(nec *M. smythiesi* var. *fortior* Forel, Rev. Suisse Zool. 1904, 12: 22-23, ♀.)

Worker (after Crawley): Length 5.0 mm.

"Head broader than in *bergi*, the sculpture of the head and thorax coarser and more broken and that of the nodes much coarser than in the type. Entire body darker than in *bergi:* in all other respects similar to *bergi*.

Type Locality: Iran (N. W. Persia): Enzeli (P. A. Buxton, 1919).

In Dr. Wheeler's collection is what appears to be a cotype with the above locality label. The head is 0.67 as broad between the eyes as long (with mandibles), the mesoëpinotal suture is deeper than that of the *bergi* cotype, the sculpturing is coarser and the color is darker. The Kazakstan specimens listed under *bergi* are intermediate between this variety and the typical form.

Myrmica bergi subsp. **kamyschiensis** Arnoldi

M. bergi kamyshiensis Arnoldi, Folia Zool. et Hydrobiol., Riga, 1934, 6: 159, ♀.

A form from Transcaucasia unknown to me.

THE INSECT CRANIUM AND THE "EPICRANIAL SUTURE," by R. E. SNODGRASS. 52 pages, 15 figures. Smithsonian Miscellaneous Collections, Vol. 107, No. 7, 1947.

One can hardly claim to be an entomologist if he must acknowledge ignorance of the author's dominant position in the study of insect morphology, hence it is almost superfluous to comment on the high quality and significance of this contribution.

The study stems from an article by Du Porte (1946) which asserts that the epicranial suture "has no structural significance at all, being merely a line of weakness in the head wall where the cuticle splits at ecdysis, with its arms taking quite different courses in different insects," and that muscle attachments are not dependable criteria for the determination of skeletal homologies. According to Snodgrass' introduction the first idea had already been developed in his manuscript but he disagrees with the second and introduces the relations of the nervous system as an additional factor in the problem.

Data are presented on the "ecdysial cleavage line of the head" in Apterygota and fourteen orders of Pterygota, illustrated with great clarity in the series of text figures. In conclusion the author states that the "insect cranium is *not* composed of 'plates' united by 'sutures'," but he finds a definite relationship between the position of the epicranial suture and the muscle attachments in the head. The term frons assumes an indefinite anatomical significance and the facial apotome is shown to vary according to the extent of the arms of the suture, in some cases including the median part of the frons and in some an additional median part of the clypeus.

The article concludes with a bibliography of fifty-four titles.—A. W. L.

THE RELATION BETWEEN POISON CONCENTRATION AND SURVIVAL TIME OF ROACHES INJECTED WITH SODIUM AND POTASSIUM CYANIDES AND POTASSIUM FERRICYANIDE

SAM C. MUNSON AND J. FRANKLIN YEAGER,
U. S. Department of Agriculture, Agricultural Research Administration, Bureau of Entomology and Plant Quarantine

In preceding papers (3, 4, 5) the authors described and analyzed concentration-survival time curves pertaining to roaches injected with arsenicals. The present paper is a study of the relationship between concentration of poison and survival time of large nymphs of the American roach (*Periplaneta americana* (L.)) injected quantitatively with sodium cyanide (NaCN) (experiments 1 A, 1 B, 1 C), potassium cyanide (KCN) (experiment 2), and potassium ferricyanide ($K_3Fe(CN)_6$) (experiment 3).

METHODS

The NaCN and KCN were dried in a calcium chloride desiccator. Each NaCN, KCN, and $K_3Fe(CN)_6$ solution was prepared shortly before being used. Injections of the NaCN solutions were performed in the way described previously (4). The KCN and $K_3Fe(CN)_6$ solutions were injected in the same way except that the solutions were drawn into and forced out of the injection pipette by the pressure of a screw on a rubber bulb attached to the pipette, instead of by the use of a mouthpiece. Insects which bled during or just after injection were replaced by others injected successfully. When the higher concentrations of the potassium salts were injected, replacements because of hemorrhage were frequent and there was considerable uncertainty as to whether later on some of the successfully injected insects might have bled slightly. Because of these difficulties the number of insects used to determine a point on the KCN or the $K_3Fe(CN)_6$ curve was not always the same. After the insects were injected they were kept in vials, as described previously (4), at a temperature of 80°–85° C. and a relative humidity of 40–80 per cent, and were examined periodically for symptoms of poisoning and death.

Since in these experiments each insect received 0.020 ml. of a molar solution of poison per gram of body weight, a *stated* molar concentration is *twice* the molar concentration actually injected; this facilitates the comparison of these with other results for insects injected with 0.010 ml. per gram of body weight of molar concentrations of other poisons. The stated concentrations were used in calculating survival times.

The times of appearance of certain symptomatic stages, symbolized by A, A—, S, L, M_1, M_2, and D as described previously (3), were recorded during these experiments. The symptomatic picture of these cyanide-poisoned roaches was compared with that of the arsenic-poisoned roaches by the graphical method already described (3). During arsenical poisoning the symptoms A to D were progressive from

A, which represents an apparently normal condition, to D, representing death. The development of symptoms in arsenical poisoning is used as a standard of reference. A change in the opposite direction, as from M_1 or M_2 toward A, exhibited by many of the cyanide-poisoned roaches, represents partial or complete recovery. In this paper, the number of minutes from the time of injection to the time at which an insect recovered from D (narcosis) to a given symptomatic stage is referred to as the recovery time.

RESULTS AND DISCUSSION

The relationship between concentration and survival time may be interpreted more readily if first the symptomatic picture of the roaches injected with the different concentrations of these cyanides is considered. In general, as will be shown, each of these poisons can produce two effects in an injected insect, a narcotic and a lethal

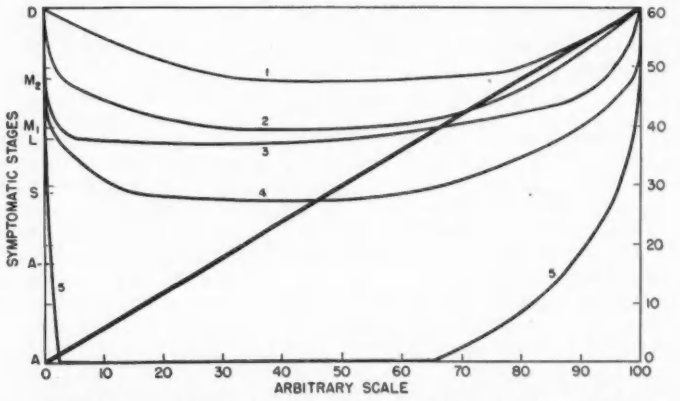

FIG. 1. Development of symptomatic stages A, A–, S, L, M_1, M_2 and D by roach nymphs injected with sodium cyanide (curves 1–5), compared with that of nymphs injected with sodium metarsenite (diagonal straight line). The numerical values of the symptomatic stages are on the vertical axis to the right. Curves 1, 2, 3, 4, and 5 refer, respectively, to the concentrations 0.2040, 0.1224, 0.08160, 0.07140, and 0.04080.

effect. Complete narcosis is indicated by the failure of an insect to respond to mechanical stimulation. As permanent inability to respond to mechanical stimulation was used as a criterion for death, it was not certain whether an insect permanently inactivated by one of the poisons was narcotized or dead, until putrefaction had set in or some other sign of death had appeared.

In figure 1 the symptomatic picture exhibited by roaches poisoned with NaCN is compared, by the graphical method described earlier, with that reported previously for roaches poisoned with sodium metarsenite. Whereas, once symptoms appeared, the arsenite-poisoned roaches progressed continuously along the diagonal straight line from A to D and usually without any recovery, the roaches injected with

certain concentrations of KCN passed very rapidly from A to D (narcotic effect). After this they showed partial or complete recovery, depending upon the dose of poison, and passed along the curved lines to D as the lethal effects of the poison took place. When the injected

TABLE I

ARITHMETIC MEANS OF RECOVERY TIMES OF ROACHES INJECTED WITH NaCN OR KCN

CONCENTRATION (molar)	MINUTES TO RECOVER TO—				
	M_2	M_1	L	S	A
	Experiment 1 C (NaCN)				
0.3060	1203+	.....	.....	.....	.....
.2550	799+	.....	.....	.....	.....
.2040	571	.....	.....	.....	.....
.1632	212	.....	.....	.....	.....
.1428	351	.....	.....	.....	.....
.1326	273	796+	.....	.....	.....
.1224	144	1443	.....	.....	.....
.1122	116	510	.....	.....	.....
.1020	128	507	.....	.....	.....
.09180	84	505	2338+	.....	.....
.08160	41	208	636	7630+	.....
.07140	52	294	1000	3838	.....
.06120	22	107	211	373	2885
.04080	2	49	108	143	1228
.03060	0.5±	35	80	104	500
.02040	0.5±	13	37	50	90
.01020	0.5±	5	15	28	71
.00510	0.5±	7	8	25	68
Controls	.....	.....	.....	.....	.....
	Experiment 2 (KCN)				
0.2304	685+	.....	.....	.....	.....
.1935	352+	.....	.....	.....	.....
.1536	232+	368+	.....	.....	.....
.1229	95	441+	.....	.....	.....
.09830	7	188	322	421+	577+
.07680	5	70	240	460+	629+
.05760	7	73	250	682+	1640+
.03840	4	21	98	287	591
.01920	.....	9	41	160	268
.007680	2	6	7	15	27
Controls	.....	.....	.....	.....	.....

concentration was sufficiently high, the insects passed rapidly to D and thereafter showed no recovery. For such insects death took place before any detectable recovery from the narcotic effect was possible, and the end point D probably represented complete inactivation due

to narcosis rather than death. When the injected concentration was sufficiently low, inactivation by narcosis was not complete and was of short duration. Curves 1 to 5 illustrate the different extents of recovery from the narcotic effects of different concentrations of poison and the subsequent approach to D, representing death. The arbitrary value on the horizontal axis is converted to observed recovery time in minutes when multiplied by the appropriate factor: curve 1, 17.25; curve 2, 47.28; curve 3, 104.1; curve 4, 323.5; curve 5,500.0.

The symptomatic picture of KCN is about the same as that for NaCN and, therefore, is represented approximately by Figure 1. The symptomatic picture for $K_3Fe(CN)_6$ seemed to be similar, but complete observations of symptoms were not made in experiment 3. The recovery times are shown in Table I for NaCN and KCN.

The injection into a roach of one of these three cyanide poisons usually was followed by a marked increase in bodily activity accompanied by violent tremors, particularly noticeable in the appendages. Tremors were produced by the sublethal as well as by the higher concentrations. The activity and tremors were most marked during the initial rapid passage from A toward M_2 or D.

None of the roaches injected with NaCN showed any recovery at concentrations higher than about 0.4 M, Table II and Figure 2, and most roaches showed no recovery at 0.3060 M. It is very likely that they were permanently inactivated by the narcotic effect of the poison and died later while still narcotized. The reasons for this opinion are (1) that the insects did not have the appearance of insects known to be dead, (2) that insects inactivated by the high concentrations of the poison did not putrefy as soon as they were expected to, (3) that at certain concentrations some insects of a group showed partial recovery whereas the others did not, and finally (4) that in experiment 2 (KCN) many of the insects, including some of the controls, developed a red color about 6 hours after they were known to have died, whereas the insects inactivated by high concentrations of the poison developed the red color much longer after becoming inactivated. The approximate times to appearance of the red color are included in Table III; these times minus 360 minutes offer a very rough basis for estimating real survival times.

Previous work (3, 4) showed that a complete concentration-survival time curve for roaches injected with an arsenical possessed a critical zone. The critical zone is a portion of the concentration range within which the groups of insects used to determine a point on the curve tend to form a bimodal frequency distribution with respect to survival time, or to form two separate distributions. Within the critical zone the different measures of central tendency fail to agree well in value. Each cyanide concentration-survival time curve described in this paper has two critical zones, one for the narcotic and one for the lethal effect, the latter corresponding to the critical zone of the arsenical curves. A critical zone for narcosis was not evident for the times of appearance of red color. Within these two critical zones it has not been possible to obtain satisfactory mean values for the survival times. This has been a serious interference with the obtaining of good fits to the experimental data through the use of the equations developed previously (4).

The obtaining of close fits to the observed data is rendered difficult also by the fact that, whereas the survival-time curves for arsenicals are death curves throughout, these cyanide curves are composite. Apparently they are narcosis curves for the upper lethal concentrations,

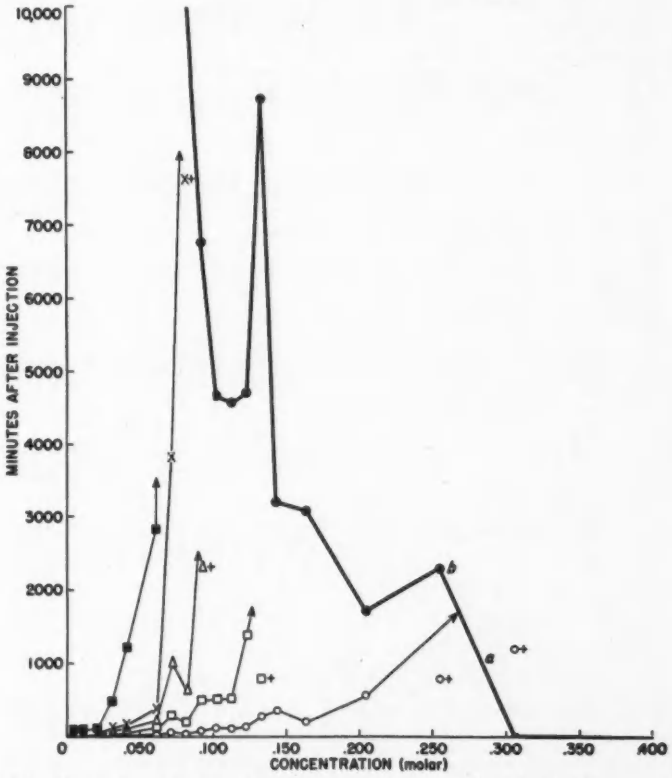

FIG. 2. Part of a concentration-survival time curve (solid dots) for nymphs injected with NaCN (experiment 1, C). Recovery curves also are shown (■, ×, △, □, and ○, represent A, S, L, M_1, M_2, respectively). Survival time and recovery time in minutes are on the vertical axis. A vertical distance between two recovery curves represents the time an insect was in the symptomatic stage represented by the lower curve. Each survival time is the arithmetic mean of the larger of the subgroups in a bimodal frequency distribution in a critical zone.

transitional at intermediate concentrations, and death curves only for the lower lethal concentrations of injected poison.

Tables II and III show the arithmetic and harmonic means of survival times for each group of insects injected with a given concentration of poison. Corresponding values for the larger subgroup

TABLE II

OBSERVED SURVIVAL TIMES OF ROACHES INJECTED WITH SODIUM CYANIDE. THE VALUES INDICATED BY ASTERISKS ARE PLOTTED IN FIGURE 2

CONCENTRATION (molar)	EXPERIMENT 1 A				EXPERIMENT 1 B				EXPERIMENT 1 C			
	SURVIVAL TIME (minutes)			Number of Insects	SURVIVAL TIME (minutes)			Number of Insects	SURVIVAL TIME (minutes)			Number of Insects
	Median	Arithmetic Mean	Harmonic Mean		Median	Arithmetic Mean	Harmonic Mean		Median	Arithmetic Mean	Harmonic Mean	
0.8160	5	5	5	10	5	5	5	10	5	5	5	20
.6120	5	5	5	10	5	5	5	10	5	5	5	20
.4080	5	290	5	10	5	5	5	10	5	199	5	20
	(5)	(5)	(5)	7	...	...	...	...	(5)	(5)	(5)	17
.3060	...	...	...	...	...	...	...	...	5	834	5	10
	...	...	...	...	...	...	...	...	(5)	(5)*	(5)	7
.2550	...	...	...	...	...	...	...	...	2160	1840	13	10
	...	...	...	...	...	...	...	...	(2160)	(2299)*	(1579)	8
.2040	472	832	7	10	2197	3440	18	10	805	2136	5	20
	(667)	(1039)	(644)	8	(2198)	(2410)	(1137)	8	(1188)	(1725)*	(723)	16
.1632	1193	1545	15	10	3375	4312	2019	10	1515	2929	29	20
	(1310)	(1716)	(1253)	9	...	...	...	...	(1710)	(3083)*	(1565)	19
.1428	...	...	...	...	2315	2920	1382	10	2315	2920	1382	10
	...	...	...	...	(2320)	(3214)	(2540)	9	(2320)	(3214)*	(2540)	9
.1326	...	...	...	...	10800	19008	10193	10	10800	19008	10193	10
	...	...	...	...	(9360)	(8743)	(7881)	7	(9360)	(8743)*	(7881)	7
.1224	4560	4087	3327	10	6480	10760	5160	10	5040	7423	4046	20
	...	...	...	...	(4320)	(5530)	(4267)	8	(4560)	(4728)*	(3709)	18
.1122	...	...	...	...	5040	13692	4468	10	5040	13692	4468	10
	...	...	...	...	(5040)	(4594)	(3237)	7	(5040)	(4594)*	(3237)	7
.1020	2263	3380	1983	10	7920	10800	5379	10	4320	7040	2898	20
	(2262)	(3552)	(2452)	9	(5040)	(5940)	(4517)	8	(3600)	(4682)*	(3124)	17
.09180	5760	12959	4141	10	14400	20550	6174	10	9360	16754	4957	20
	(3600)	(4236)	(3012)	7	(10800)	(9300)	(4572)	7	(4320)	(6768)*	(4410)	14
.08160	18720	25448	6565	10	14760	20232	10901	10	16560	22860	8195	20
	(7420)	(9600)	(4164)	6	(7920)	(11109)	(8331)	7	(9360)	(10412)	(5699)	13
.07140	15120	20919	5552	10	54000	43776	19190	10	27360	32347	8612	20
.06120	36720	35144	11920	10	39600	44640	18120	10	38160	38092	14380	20
.04080	47520	41616	25200	10	47520	58608	25300	10	47520	50112	25330	20
.03060	...	...	...	...	42480	46160	14270	9	42480	46160	14270	9
.02040	46800	42476	33790	10	23750	27216	19930	10	34560	34846	25070	20
.01020	43200	47232	43620	10	36000	39600	34800	10	38160	43416	38710	20
.00510	51120	53568	38785	10	...	...	...	...	51120	53568	38785	10
Controls	44640	44208	28055	10	41040	45792	40400	10	43200	45000	33110	20

TABLE III

OBSERVED AND CALCULATED SURVIVAL TIMES OF ROACHES INJECTED WITH POTASSIUM CYANIDE (EXPERIMENT 2), AND TIMES TO APPEARANCE OF RED COLOR IN THE BODIES OF THE INSECTS

CONCENTRATION (molar)	OBSERVED TIMES					CALCULATED[1] SURVIVAL TIME (minutes)	NUMBER OF INSECTS
	Survival Time (minutes)			Time to Appearance of Red Color (minutes)			
	Median	Arithmetic Mean	Harmonic Mean	Arithmetic Mean	Harmonic Mean		
0.4608	5	5	5	2959	2623	1338	5
.3072	6	1949	5	4597	3824	1956	7
	(5)	(5)	(5)	.....	.....	.....	4
.2304	2733	2911	12	3548	2864	2488	8
	(3444)	(3326)	(2483)	.....	.....	.....	7
.1935	2100	1844	46	5100	3730	2822	8
	(2786)	(2688)	(2557)	.....	.....	.....	5
.1536	1536	1999	6	3809	2756	3224	9
	(2330)	(2569)	(2042)	.....	.....	.....	7
.1229	2386	3049	2537	3818	2967	3495	10
.09830	30240	32054	10557	32240	10888	3585	10
	(5730)	(9012)	(5879)	(9300)	(6082)	.....	5
.07680	3873	4879	3561	5065	3651	3445	12
.05760	3170	6976	3597	7084	3703	3029	9
	(3012)	(4518)	(3246)	(4640)	(3343)	.....	8
.03840	8865	22222	6880	22765	7995	4939	9
	(5463)	(5530)	(4147)	(6129)	(4874)	.....	5
.01920	52560	46825	13835	47075	14310	13398	13
.007680	51840	50832	48170	.....	.....	.....	10
Controls	41040	44352	36560	44928	36835	.....	10

[1]Calculated by equation (14) [see 4] to fit the harmonic means in the preceding column after the subtraction of 360 minutes from each of those means.

TABLE IV

RANGE OF MOLAR CONCENTRATIONS IN THE CRITICAL ZONE AND THE REGION OF INFLECTION FOR POISONS INDICATED

POISON	EXPERIMENT NO.	CRITICAL ZONE FOR—		REGION OF INFLECTION	
		Narcosis	Death	Including c_o	Minus c_o
NaCN	1 A	0.4080–0.1632	0.1020–0.0612	0.1224–0.1020	0.0724–0.0520
	1 B	.2040– .1428	.1326– .0612	.1326– .1122	.0826– .0622
	1 C	.4080– .1428	.1326– .0612	.1326– .1020	.0826– .0520
KCN	2	.3072– .1536	.0983– .0192	.0983– .0576	.0903– .0496
$K_3Fe(CN)_6$	3	.7292– .3646	.1823– .0608	.....	.....

of the bimodal frequency distribution at each concentration within the critical zones are shown in parentheses. These tables and Figure 2 show that, beginning at the highest concentration, as concentration decreases, a curve suddenly departs from near the concentration axis, going to, say, about 2000 minutes (NaCN curve), then passes through a region containing the critical zone for narcosis into a region of inflection, analogous to the region of inflection described previously for roaches injected with arsenicals. This region of inflection is overlapped by the upper part of the critical zone for death. The curve then passes through the lower part of the critical zone for death and reaches the survival-time neighborhood of the controls, where a survival-time value exceeding that of the controls may be attained. The limits of the two critical zones, and of the region of inflection before and after subtracting c_o[1], are given in Table IV for the three cyanide poisons.

At higher concentrations the errors involved in experiments 2 (KCN) and 3 $K_3Fe(CN_6)$ no doubt are greater than those in experiment 1 (NaCN), because the potassium salts seemed to facilitate hemorrhage. Nevertheless, the data indicate that, in general, the KCN curve is similar to the NaCN curve. Concentrations of $K_3Fe(CN)_6$ higher than 0.7292 M were not used because of excessive hemorrhage. The data indicate that, for the concentrations used, the $K_3Fe(CN)_6$ curve resembles the NaCN and KCN curves, except that a region of inflection is not apparent.

Figure 2 shows that the recovery curves rise fanwise from near the origin of the coordinate axes toward the concentration-survival time curve. The time between injection and recovery to a given symptomatic stage is represented by the vertical distance on the graph from the concentration axis to the recovery curve. Thus, at 0.2040 M NaCN, an average insect went from A to D (narcosis) in less than 5 minutes, remained D up to about 570 minutes, at which time it became M_2, remained M_2 from about 570 to about 1700 minutes, when it died without further recovery. At 0.06120 M NaCN another average roach went to D (narcosis) in less than 5 minutes, was D from then to 22 minutes, was M_2 from 22 to 107, M_1 from 107 to 211, L from 211 to 373, S from 373 to 2885 minutes, after which it became A, indicating complete recovery from the narcotic effect of the poison. The recovery curves indicate that a maximum of recovery, not necessarily complete recovery, is reached. For some of the recovery curves in Figure 2 the symbol at certain concentrations has a + sign by it and the curve is drawn to the left of the symbol because some of the insects did not recover from the narcotic effect, and actually the average recovery time would be greater than the value indicated. It may be noted that at each lethal concentration the insects reached their maximum recovery roughly about halfway between the time of injection and the time of death. Although graphically it might seem that these recovery curves should continue until they reach or cross the concentration-survival time curve, only the M_2 curve would reach approximately the death curve, for only the M_2 symptomatic stage immediately precedes

[1] c_o corresponds to a minimum lethal dose; see (*4*).

death. Insects in an M_1 stage, for example, would again have to pass through an M_2 condition before death. This is illustrated in Figure 1. The M_2 curve (Fig. 2) reaches approximately the concentration-survival time curve somewhere between the points a and b, probably as shown in the figure. This approximate meeting of the two curves helps to explain the sudden departure of the concentration-survival time curve from the concentration axis toward the point b.

The concentration ranges in which different factors are considered to influence the form of the survival time curves for NaCN and KCN are indicated by the letters in the double column under "Concentration Range" in Table V. The approximate limits of each range are indicated by the short horizontal lines that separate the letters in the column. The concentrations that fall within each range may be read from the first column, headed concentration; for example, range B extends from just above 0.4080 M to just below 0.1428 M. Since some of the ranges overlap, the survival time associated with one concentration is affected by more than one factor and it is necessary to show them by a double column in the table. The characteristics of each concentration range, the limits of which are indicated in parentheses for experiment 1 C (NaCN), are as follows: (1) Range A (down through 0.6120), narcosis is the principal result measured; (2) Range B (0.4080–0.1428), critical zone for narcosis; (3) Range C (between 0.3060 and 0.2550), transition from narcosis to death, as the principal result measured; (4) Range D (0.2550–0.1326), range in and below which primarily death is measured; (5) Range E (0.1326–0.04080), critical zone for death; (6) Range F (0.1224–0.1020), region of inflection; (7) Range G (0.09180–04080), survival times progress regularly toward the survival time of the controls as concentration decreases; (8) Range H (0.3060–controls), survival times may be approximately equal to or greater than that of the controls; (9) Range I (below 0.00510), survival times are approximately the same as the survival time of the controls. A zero appears in the parts of the double column where no range is specified.

Considering the complexity of each of these concentration-survival time curves, one would hardly expect to obtain a single straight line by plotting the logarithm of concentration against the logarithm of observed survival time. When such a graph is made, the curve consists of several portions (probably as many as seven), in each of which a straight line could be drawn through the points. An expression such as $(c-c_o)t_s = K$, where c is injected concentration, c_o is minimum lethal concentration, and t_s is survival time, does not represent adequately one of these concentration-survival time curves as a whole, but values of $(c-c_o)t_s$ are given in Table V. For example, in the range G, the average values of K and the values of c_o are K = 147, c_o = 0.008 for KCN, and K = 177, c_o = 0.05 for NaCN.

Because of the composite nature of these cyanide curves, particularly because the measures of central tendency are less exact in the critical zones, it has not been possible satisfactorily to calculate survival times from these data by means of the equations developed in the previous papers dealing with arsenicals. Nevertheless, approximate survival-time values, given in Table III, for roaches poisoned with KCN were calculated by means of equation (14) described previously (4).

TABLE V

OBSERVED SURVIVAL TIMES OF INJECTED ROACHES, VALUES OF K AND CONCENTRATION RANGES[1] FOR EXPERIMENTS 1 C (NaCN) and 2 (KCN)

CONCENTRATION (molar)	CONCENTRATION RANGE	SURVIVAL TIME (minutes)	K[2]
Experiment 1 C (NaCN)			
0.8160	A O	5	3.8
.6120		5	2.3
.4080	B	5	1.8
.3060	C	5	1.3
.2550	D	1579	324
.2040		723	111
.1632		1565	177
.1428		2540	236
.1326	E	7881	651
.1224	F	3709	269
.1122		3237	201
.1020		3124	162
.0918	G	4410	184
.0816		5699	180
.0714		8612	184
.0612		14380	161
.0408		25330	....
.0306	H O	14270	....
.0204		25070	....
.0102		38710	....
.0051		38785	....
Controls	I	33110	....
Experiment 2 (KCN)			
0.4608	A	5	2.3
.3072	B	5	1.5
	C		
.2304	D	2483	552
.1935		2557	449
.1536		2042	297
.1229	O	2537	292
.0983	F E	5879	531
.0768		3561	245
.0576	G	3246	161
.0384		4147	126
.0192	O	13835	155
.00768	H	48170	....
Controls		36560	....

[1]See text, p. 483.
[2]$K = (c - c_0)t_s$.

Above the region of inflection these values might be considered to represent probable survival times of the inactivated roaches as indicated by the appearance of red color in their bodies. Below the inflection the calculated and the observed harmonic means agree about as well as could be expected, if the complexity of the curve and the errors involved are considered. The values of the constants used in making these calculations were $K = 150$, $c_o = 0.008$, $a = 5$, $p = 0.25$, $c_d = 0.0576$, $n = 2$, and $m = 2$.

A comparison of the NaCN and KCN curves (Fig. 2, Tables II and III) shows that the inflection occurs at higher concentrations of NaCN than of KCN. If, however, the comparison is made on the basis of the approximate effective concentration ($c - c_o$), instead of the injected concentration (c), the regions of inflection agree more closely (Table IV).

The data for $K_3Fe(CN)_6$ (Table VI) show that this poison is much less toxic when injected into the roach than is either NaCN or KCN. According to the generalized hypothesis proposed earlier in connection with sodium metarsenite the presence of an inflection in the NaCN and the KCN curves indicates that each of these poisons in solution within the organism exists as two different chemical species in equilibrium with each other, of which the one, x, is toxic and the other, y, is not toxic. The chemical identification of x and y is not made possible by the hypothesis but is a matter of physico-chemical interpretation. An interpretation, similar to that used in connection with sodium metarsenite, based upon an assumed incomplete ionization of the injected poison, would identify y as NaCN or KCN molecules and x as CN ions, corresponding respectively to sodium metarsenite molecules and arsenite ions postulated for the sodium metarsenite-injected roaches (4). But an alternative interpretation is considered more likely to be correct not only for the NaCN and KCN data presented here but also for the arsenical data reported earlier. According to this second interpretation the injected NaCN or KCN is completely ionized and the non-toxic cyanide ions, y, are in equilibrium with toxic hydrocyanic acid molecules, x, formed by hydrolysis of the cyanide ions; and the degree of hydrolysis varies inversely with total concentration of poison down to a critical concentration, c_d, below which complete hydrolysis is assumed. For the arsenite data, similarly interpreted, y would be arsenite ions, instead of sodium metarsenite molecules, and x would be arsenious acid molecules formed by hydrolysis of the arsenite ions, instead of arsenite ions. The toxic symptoms produced in roaches by $K_3Fe(CN)_6$ were similar to those caused by KCN and NaCN, suggesting that all three poisons may affect the same tissue components, perhaps the same enzyme systems of the tissues. If it be supposed that these tissue components are affected by all three cyanides in the form of a single chemical species, x, CN ion according to the first interpretation or hydrocyanic acid molecules according to the second, it would appear that relatively not more than 3 per cent of the potentially available CN from the $K_3Fe(CN)_6$ must have participated in the lethal action of the poison. With respect to any liberation of the CN component, this would seem to indicate that the ferricyanide radical has considerable stability, and may be

partly responsible for the failure of the $K_3Fe(CN)_6$ data to indicate a region of inflection.

The fact that cyanide may produce a narcotic as well as a lethal effect upon an organism has been recognized for a considerable time in the literature dealing with the biological action of cyanides. In entomological literature this effect sometimes is designated by another term. For example, Bliss and Broadbent (1, 2), in reporting an extensive statistical analysis of the effects of hydrocyanic acid gas upon *Drosophila*, refer to a stupefaction effect. The authors have not found reports of extensive, cyanide concentration-survival time curves with

TABLE VI

OBSERVED SURVIVAL TIMES OF ROACHES INJECTED WITH $K_3Fe(CN)_6$

CONCENTRATION	SURVIVAL TIME			NUMBER OF INSECTS
	Median (minutes)	Arithmetic Mean (minutes)	Harmonic Mean (minutes)	
0.7292	256	241	235	4
.6076	930	2264	278	10
	(780)	(1222)	(251)	9
.4680	3600	4498	1287	10
.4254	4320	5520	1323	10
	(5040)	(5501)	(3032)	9
.3646	7420	6882	4707	10
.3038	9360	8496	7940	10
.2430	7920	8424	7071	10
	(7920)	(9040)	(8440)	9
.1823	7920	11320	9757	10
.1215	25200	26208	14140	10
.06076	27800	33984	21715	10
.006076	46080	47520	37640	10
.003038	36000	37872	33975	10
.001519	53280	53856	35140	10
Controls	32200	37276	31740	10

which to compare those reported here. It is of considerable interest, however, that Graham[2], in a study of the effects of a number of poisons on the respiration of tissues from the codling moth, obtained curves relating concentration of poison to inhibition of oxygen consumption, and that these curves show regions of inflection that may be analogous to those reported here for cyanide and previously for the arsenicals. The inflections found by Graham and by us for sodium cyanide and for sodium metarsenite occur at concentrations of poison that are not greatly different, when allowance is made for a dilution of the injected poison by the blood of the roach.

[2]Graham, Kenneth. Respiratory enzyme mechanisms and inhibitor action in tissues of codling moth larvae. [Unpublished thesis, University of Toronto, Canada], 1945.

SUMMARY AND CONCLUSIONS

Concentration-survival time curves and concentration-recovery time curves for large nymphs of the American roach (*Periplaneta americana* (L.)) injected with NaCN, KCN, and $K_3Fe(CN)_6$ were obtained. The potassium salts facilitated hemorrhage, thereby increasing experimental error. The symptomatic picture of these poisoned roaches was compared with that of roaches poisoned with sodium metarsenite used as a standard. The cyanide curves are complicated by the fact that the cyanides have both a narcotic and a lethal effect upon the injected insects. Whereas, once symptoms appear, arsenite-injected roaches progress continuously toward death, the cyanide-injected roaches may become completely inactivated (narcotized), partially or completely recover, and pass through successive symptomatic stages to death. The cyanides produce tremors temporarily, particularly during the early stages of poisoning. A cyanide concentration-survival time curve is complicated not only by the occurrence of both narcotic and lethal effects of the poisons but also by the existence of two critical zones, one for narcosis and one for death, and by the presence of a region of inflection analogous to the inflection in curves of arsenite-injected roaches reported previously. Thus, these cyanide curves are composite, representing time for complete narcosis in the upper concentrations and survival time in the lower lethal concentrations. In the intermediate concentrations they are transitional. These complexities render mathematical treatment of the data difficult. The $K_3Fe(CN)_6$ appears to be less toxic than NaCN or KCN to the roach, possibly because of considerable stability of the ferricyanide radical.

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LARVAE OF SOME GENERA OF ANTHRIBIDAE

(Coleoptera)

W. H. ANDERSON
Bureau of Entomology and Plant Quarantine,
U. S. Department of Agriculture

Most investigators who have been concerned with the relationships of the Anthribidae have believed that the family is at least related to the Rhynchophora. Several have included the family in that large group. Leconte (1876) stated that the Anthribidae should be placed in the Rhynchophora, since there were not sufficient reasons for excluding them. Böving and Craighead (1931), drawing their conclusions principally from studies of the larvae, have treated the Anthribidae as a superfamily, equal in rank to the Chrysomeloidea and the Curculioidae. They have placed that superfamily, in a linear arrangement, between these latter two but have not indicated that they believed the Anthribidae more closely related to the Curculionidae than to the Chrysomelidae. Gardner, who has published one comprehensive paper (1936) and two smaller ones (1932, 1937) on the larvae of the Anthribidae of India, believes that the family belongs in the Rhynchophora. Emden (1938) also places it there. Crowson (1944), who has studied the metendosternite in Coleoptera, considers the Anthribidae to comprise one of six families of Rhynchophora.

The most recent paper to deal with the subject is that by Hoffman (1945). Unfortunately, however, Hoffmann's conclusions seem based upon faulty observation or misinterpretation. He places the Anthribidae and the Urodonidae (sic) (*Bruchela*) in the Chrysomeloidea. He states that the Chrysomeloidea are distinguished from the Curculionoidea by the presence in the larvae of the latter of a hypopharyngeal bracon which is absent in larvae of the Chrysomeloidea. Yet the anthribids and *Bruchela*, larvae of both of which clearly possess the bracon, are placed with the Chrysomelidae.

Conclusions drawn from study of the larvae,[1] partially reported in this paper, are that the Anthribidae represent a rather homogeneous section of the Rhynchophora. They possess the characteristics of larvae of the Rhynchophora considered essential to separate them from other families of the Polyphaga. These characteristics are: Gular region or median gular suture absent; hypopharyngeal bracon present (except *Rhynchaenus* and *Rhamphus*, fide Emden (1938), *Attelabus*, *Apoderus* and probably others); urogomphi (in the strict sense) absent; tenth abdominal segment in front of anus without a pair of soft, oval lobes separated by a longitudinal groove; mala not borne on palpiger; legs

[1] I have not studied larvae of the Scolytidae, Platypodidae and smaller, related families. Generalizations on rhynchophorous larvae may or may not apply to those families.

usually absent, when present without claw; clypeus almost always well defined; spiracles not cribriform.

With a few exceptions, such as *Bruchela* by which they may be related to the Bruchidae[2] and *Cimberis* through which they appear to be related to the remainder of the Rhynchophora, the Anthribidae can be characterized readily. The purpose of this paper is to define the family, indicating how it may be separated from other Rhynchophora, and present keys to the mature larvae of the subfamilies and genera. Only the larvae which have been available for study have been included, although reference is made to some of those described by Gardner.

Keys to the species have not been prepared. Emden (1938) has shown that larvae of at least some genera of Rhynchophora are separable to species. However, specific identification is hazardous since the larvae of only 25 per cent of the species of Anthribidae known to occur in America, north of Mexico, have been studied. These larvae are distributed in approximately 50 per cent of the North American genera. It follows that identification to genus can be made with much more assurance than can identification to species. Some of the genera are represented in our fauna by only one species; in those genera specific identification is possible.

Unless indicated otherwise, identifications of all larvae included in this paper were made from reared adults. Some larvae which represent undetermined North American species and which represent undetermined genera have been included in the keys. It is expected that at some future date the identity of these larvae will be established and their position in the classification will thus be indicated. Undetermined larvae from localities outside the United States have not been included. As an example, an interesting, robust larva from seeds of *Styrax* spp., from Japan and China, has been omitted from the keys.

No satisfactory way has been devised for measuring and expressing the size of the larvae. The over-all length of mature specimens of a given species will vary considerably depending upon the method of killing before preservation. General statements have been made, however, in an attempt to indicate the comparative sizes of the larvae; as small, moderately large, and large. The length of the larvae studied ranges from about 2.5 mm. (*Choragus*) to about 15 mm. (*Platyrhinus*). As an added guide to size, the greatest width of the head for any representative of the given genus has been indicated.

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[2]In a former paper (1943) I have discussed the essential differences between the Anthribidae, including *Bruchela*, and the Bruchidae. Since that paper was published it has been discovered that the tracheal system of bruchid larvae provides an additional means of separating the families. In the tracheal system of all bruchid larvae available for study (approximately 37 species representing 17 genera, see Bridwell (1946)), with the exception of *Acanthoscelides alboscutellatus* (Horn) and *A. calvus* (Horn), there is a series of air sacs. In the majority of species these consist of four separate, distinctly enlarged chambers in the main tracheal branches on each side of the body, three closely associated with the first abdominal spiracle, the fourth with the second abdominal spiracle. In other species, at least generically distinct from those with 4 pairs, there may be 9 or 10 pairs, distributed along the tracheal system in the abdominal segments. No enlargements of the branches of the tracheae have been observed in the larvae of Anthribidae, including *Bruchela*, nor in any other rhynchophorous larva. The function of these sacs is not apparent.

The following couplet is offered as a means of separating the larvae of Anthribidae from those of other Rhynchophora.

Ultimate and penultimate articles of maxillary palpus each with a short seta (figs. 38, 42); labral rods[3] absent; labral tormae present (figs. 45, 47, 51) or rarely absent; legs usually discernible.....**Anthribidae**

Without the combination of characters given above. Ultimate article of maxillary palpus without seta (except *Belus* in which antenna consists of two subcylindrical, sclerotized articles, and Attelabinae (including *Rhynchites* and its allies) in which labral rods are present and long); labral rods present (except *Belus* and *Proterhinus*) occasionally modified; labral tormae absent (except *Belus* in which palpiger is present and bears distinctly more than three setae, and *Proterhinus* in which the ultimate article of maxillary palpus is without seta); legs not discernible (except some Brentidae such as *Arrhenodes* and *Brentus*).....**Rhynchophora** (major part)

FAMILY CHARACTERIZATION

Body setae sparse to abundant, at least moderately abundant ventrally on prothorax (except *Bruchela rufipes* (Oliv.)). Hypopharyngeal sclerite usually present and well developed. Antenna consisting of one membranous article which bears a conical to subconical sensory appendage. Anterior margin of frons, between the catapophyses, considerably wider than basal margin of clypeus (except *Bruchela rufipes*). Labrum with one pair of basal sensilla, without anterior or median sensilla. Labral rods absent, labral tormae present or, rarely, absent (*Bruchela rufipes* and *Cimberis pilosus* (Lec.)). Posterior margin of prementum straight or nearly straight, not distinctly angulate (labium not subdivided in *Holostilpna*). Mentum and submentum distinguishable (except *Holostilpna* and *Bruchela*). Ultimate and penultimate articles of maxillary palpus each with a short seta. Palpiger absent (except *Cimberis*). Mala nearly always with thornlike lacinia near middle of inner margin. Legs usually discernible, often with two articles but without pointed tarsungulus.

Larva small to moderately large, usually subcircular in cross section. Frontal suture complete anteriorly, or at least not terminating at antenna. Hypopharyngeal bracon present. Head nearly always with moderately numerous to abundant setae. Anterior ocellus present or absent, posterior ocellus absent. Antenna nearly always with a few minute processes (? setae) in addition to sensory appendage. Labrum with four or more than four pairs of setae. Epipharynx with a pair of anteromedian sensilla (except *Bruchela* and *Cimberis*) and two pairs of peg-shaped sensilla (except *Cimberis* with one pair and *Bruchela* with none). Mandible usually with mola, the outer surface of the mandible with two setae (except *Euparius* and *Eurymycter*). Labium usually small. Labial palpi absent, or present and each with one or two articles. Premental sclerite usually present. Prementum with one pair to several pairs of setae. Submentum broad with usually more than three pairs of setae. Maxillary palpus with two or three articles. Stipes with several to numerous setae (except *Cimberes* with two). Mala with setae, the dorsal setae when present not arranged in an evident row.

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[3]For an explanation of this and other terms see Anderson (1947).

Thoracic spiracle either in mesothorax or situated between prothorax and mesothorax. Spiracle bicameral (figs. 8, 11, 12), unicameral (figs. 10, 13) or without air tubes (fig. 9).

Abdomen with eight pairs of spiracles. Spiracles bicameral, unicameral or without air tubes; the orifice oval to subcircular. Typical abdominal segments with two dorsal folds. Sternellum absent.

KEY TO SUBFAMILIES OF ANTHRIBIDAE

1. Head deeply retracted into pronotum, distinctly longer than broad (fig. 19); labial palpi absent; mentum and submentum not distinguishable, **Bruchelinae** (p. 492)

   Head free or only slightly retracted into pronotum, nearly as broad as or broader than long (figs. 16, 17, 18); labial palpi present; mentum and submentum distinguishable 2

2. Mandible without ventral process (fig. 23); mala broadly rounded or acute, the apical margin not straight (figs. 39–42); clypeus distinguishable from frons (figs. 16, 18); epipharynx with two pairs of peg-shaped sensilla (figs. 45, 47–51); (labium often considerably reduced in size), **Anthribinae** (p. 497)

   Mandible with low ventral process (fig. 22); apical margin of mala straight or slightly emarginate (fig. 38); clypeus and frons fused (fig. 17); epipharynx with one pair of peg-shaped sensilla (fig. 52); (labium not reduced in size) ..... **Cimberinae** (p. 515)

Subfamily **Bruchelinae**

Larva small, slender, gradually tapering posteriorly. Head deeply retracted into pronotum, distinctly longer than broad. Labium without palpi. Mentum and submentum not distinguishable. Abdominal spiracles unicameral.

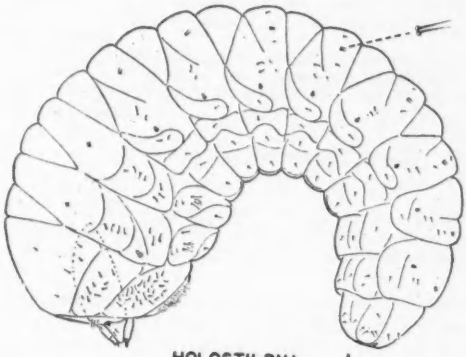
Body without pigmented sclerites. Posterior tentorial arms united or not united in the middle line. Head with few setae, these confined to anterior one-third of head capsule. Labrum with four pairs of setae. Two pairs of median spines of epipharynx present, each pair transversely arranged. Maxillary palpus with two articles. Anus terminal, i.e., in center of posterior end of body.

It is quite apparent that the larva of *Holostilpna* is not closely related to that of *Bruchela*. On the other hand it seems evident that both genera belong in the Anthribidae. If that is true, the absence of labial palpi, a striking characteristic common to both genera, makes it convenient to treat them together.

EXPLANATION OF PLATE I

Fig. 1. Lateral view of *Holostilpna nitens*, × 35. Fig. 2. Hypopharyngeal bracon of *Cimberis pilosus*, × 75. Fig. 3. Same of *Brachytarsoides alternatus*, × 50. Fig. 4. Same of *Brachytarsoides sticticus*, × 100. Fig. 5. Same of *Holostilpna nitens*, × 100. Fig. 6. Same of *Piesocorynus* sp., probably *dispar*, feeding larva, × 30. Fig. 7. Same of *Piesocorynus* sp., probably *dispar*, prepupal larva, × 30. Fig. 8. Abdominal spiracle of *Cimberis pilosus*, × 325. Fig. 9. Same of *Toxonotus fasciculatus*, × 200. Fig. 10. Same of *Brachytarsoides alternatus*, × 200. Fig. 11. Same of *Euparius marmoreus*, × 200. Fig. 12. Same of *Piesocorynus* sp., probably *dispar*, × 200. Fig. 13. Same of *Araecerus fasciculatus*, × 200. Fig. 14. Labium of *Euparius marmoreus*, × 50. Fig. 15. Same of *Discotenes nigrotuberculata*, × 100.

(All figures drawn by author)



HOLOSTILPNA 1

CIMBERIS 2

BRACHY. 3

BRACHY. 4

HOLOS. 5

6

PIESOC. 7

EUPARIUS 14

DISCOTENES 15

CIMBERIS 8

9 TOXONOTUS

10 BRACHY.

11 EUPARIUS

12 PIESOC.

13 ARAEC.

KEY TO GENERA OF BRUCHELINAE

Lateral margins of occipital foramen not interrupted; head brown; prodorsum bearing ampullalike protuberances on at least metathorax and abdominal segments I to VII; hypopharyngeal sclerite absent or indistinct, ... I. **Bruchela** (p. 494)

Lateral margins of occipital foramen interrupted by incomplete ball-and-socket joint; head lightly pigmented; prodorsum of thoracic and abdominal segments not bearing ampullalike protuberances; hypopharyngeal sclerite present, distinct ..... II. **Holostilpna** (p. 496)

I. Genus **Bruchela** Dejean

(Figs. 19, 28)

Bruchela Dejean, Catalogue de la collection de Coléoptères, p. 78, 1821.
Urodon Schoenherr, Isis von Oken, heft 10, p. 1134, 1823. (The synonymy is that of Bridwell (1932) and is based upon the acceptance of the catalog names of Dejean.)

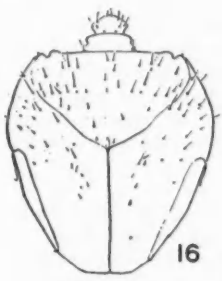
Larva oval to subcircular in cross section, scarcely thicker through thorax. Prodorsum with protuberances, at least on metathorax and abdominal segments I to VII. Head brown, with non-pigmented, longitudinal dorsal stripes. Mandible without mola. Legs or evidence of legs completely absent.[4]

Body setae sparse to numerous. Head widest near the middle, oval posteriorly. Frontal suture discernible throughout its length. Endocarina present, approximately one-half as long as frons. Lateral margins of foramen magnum not interrupted. Hypopharyngeal sclerite only indicated. Posterior tentorial arms united or not united in the middle line. Anterior one-third of head with few setae. Ocellus distinct. Antenna apparently without minute processes (? setae), the accessory appendage slender. Clypeus at most only vaguely distinguishable from frons. Anterior margin of labrum nearly straight or slightly emarginate. Labral tormae present and slender, or apparently absent. Epipharynx with one or two anterolateral and four anteromedian setae. Epipharynx apparently without sensilla; without asperities. Mandible with two subequal apical teeth and a shorter, subterminal dorsal tooth. Stipes with four (*B. rufipes*) to eight (*B. lilii*) setae. Mala with (*lilii*) or without (*rufipes*) thornlike lacinia near

[4]Each generic description is usually made up of two parts, a short review of the more important diagnostic characters followed by a more detailed description. Each description is followed by a statement of the material upon which it is based. All larvae are in the collection of the United States National Museum.

EXPLANATION OF PLATE II

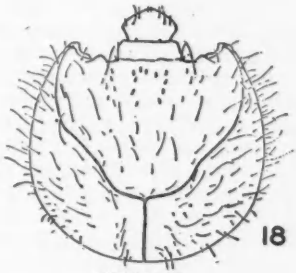
Fig. 16. Dorsal view of head of *Piesocorynus* sp., probably *dispar*, feeding larva, × 20. Fig. 17. Dorsal view of head of *Cimberis pilosus*, × 55. Fig. 18. Same of *Euparius marmoreus*, × 25. Fig. 19. Same of *Bruchela lilii*, × 50. Fig. 20. Dorsal view of left mandible of *Discotenes nigrotuberculata*, × 100. Fig. 21. Same of right mandible of *Anthribus albinus*, × 30. Fig. 22. Ventral view of left mandible of *Cimberis pilosus*, × 100. Fig. 23. Same of right mandible of *Araecerus fasciculatus*, × 55. Fig. 24. Dorsal view of right mandible of *Phoenicobiella chamaeropis*, × 30. Fig. 25. Same of left mandible of *Euparius marmoreus*, × 55. Fig. 26. Lateral view of head of *Araecerus fasciculatus*, × 25. Fig. 27. Same of *Ormiscus* sp. (Nicholson, Miss., dead persimmon limb), × 25.



16

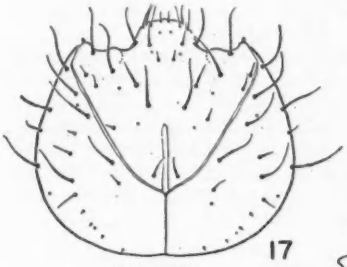
PIESOC.

DISCOT. 20



18

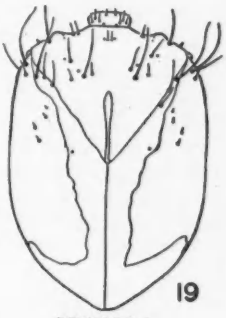
EUPARIUS



17

CIMBERIS

ANTHR. 21



19

BRUCHELA

CIMB. 22

ARAECERUS 26

PHOEN. 24

ARAEC. 23

ORMISCUS 27

25

EUPAR.

middle of inner margin. Mala with several setae on ventral surface, near apex, and with (*lilii*) or without (*rufipes*) dorsal setae.

Pronotum with setae numerous (*lilii*) or sparse (*rufipes*). Thoracic spiracle unicameral or bicameral,[5] the air tubes not annulated. Areas of thorax with comparatively few (*rufipes*) or with numerous (*lilii*) setae.

Air tube of abdominal spiracles not annulated, the peritreme subcircular. Prodorsum of typical abdominal segments with prominent, bifid, ampullalike protuberance. Abdominal areas with setae numerous or sparse, no two of the postdorsal setae contiguous at base. Asperities inconspicuous or apparently absent.

Width of head: up to 0.67 mm.

B. rufipes (Oliv.). Schönebeck a. d. Elbe, Germany, July 19, 1912, C. Urban. Presented by Emden. As reported by Urban (1913), larvae of *rufipes* feed in seed capsules of *Reseda lutea* L. In the autumn they go into the ground, forming an oval cocoon. Pupation takes place the following spring. After a short pupal period the beetles emerge and eggs are laid in young seed capsules of the host plant.

B. lilii (Fåhr.). Cape Town, South Africa, June 2, 1917, in seeds of *Gladiolus*. From the South African Museum.

Larvae of this genus have been characterized by Emden (1938) and described more completely by Urban (1913) under the generic name *Urodon*. The two species can be separated readily. In *lilii* a small sclerite is present at the base of the indistinctly developed prementum, the lacinia is represented by a small spine, and the posterior tentorial arms are united in the middle line. The larva of *rufipes* does not have a sclerite at base of prementum, the lacinia is absent and the posterior tentorial arms are not united in the middle line.

II. Genus **Holostilpna** Jordan

(Figs. 1, 5)

Holostilpna Jordan, Biologia Centrali-Americana, v. 4, pt. 6, p. 382, 1907.

Larva slightly thicker anteriorly than in the middle. Lateral margins of foramen magnum interrupted three-fifths the distance from mandibular fossa to posterior margin of head, the interruption resembling an imperfect ball-and-socket joint. Posterior tentorial arms not united in the middle line. Labium undivided, triangular. Mala without lacinia.

Prodorsum on abdominal segments without protuberances. Body setae inconspicuous, very sparse except on pedal and sternal areas of prothorax. Head not pigmented except on extreme anterior border, widest slightly behind the middle, abruptly tapering posteriorly. Frontal suture absent posteriorly, discernible anteriorly. Endocarina absent. Hypopharyngeal sclerite well developed. Internal epicranial ridge present. Ocellus absent. Antenna with one minute process (? seta) in addition to sensory appendage. Labrum slightly rounded anteriorly. Labral tormae present, short, moderately stout. Epipharynx with three anterolateral and four anteromedian setae. Two pairs of peg-shaped sensilla present on epipharynx, one pair in front of,

[5] In a previous paper (1943) I stated that all spiracles of the larvae of *Bruchela* are unicameral. That statement is in error.

the other behind, anterior pair of median spines. Epipharynx with a few slender, inconspicuous asperities posteriorly. Mandible with two apical teeth; the mola flattened or slightly concave, smooth. Labium with two elongate setae near base and two beyond the middle. Premental sclerite absent. Stipes with four or five setae ventrally and one seta dorsally. Mala with numerous ventral setae and a few dorsal setae.

Pronotum with few dorsal setae, the setae more abundant laterally. Thoracic spiracle unicameral, the air tube with poorly developed annulations. Legs absent, their position indicated by a few setae. Pedal area of prothorax with numerous setae, of mesothorax and metathorax with few setae. Sternum of prothorax with numerous setae, of mesothorax and metathorax with one or two setae on each side. Remainder of areas of thorax with setae very sparse or absent.

Air tube of abdominal spiracles weakly or not annulated. Abdominal areas with the setae sparse, two of the setae on postdorsum with their bases adjacent. Asperities very fine, generally distributed.

Width of head: up to 0.47 mm.

H. nitens (Lec.). University Park, Md., winter 1942–43, in *Hypoxylon atropunctatum* (Schw.) Cke., a fungus growing in the bark of dead black oaks, W. H. Anderson. The larvae remain in the fungus throughout the winter; pupation takes place in the fungus in the spring or early summer. The essential characteristics of the larva have been pointed out previously (Anderson, 1943).

In view of the differences in structure between the larva of *Holostilpna* and that of *Choragus* (see p. 514), there can be little doubt that *Holostilpna* should stand as a distinct genus, and not as a subgenus of *Choragus*.

Subfamily **Anthribinae**

Head free or nearly free, often with flattened area on each posterolateral surface, nearly as broad as or broader than long, the lateral margins often nearly straight and convergent behind the middle. Hypopharyngeal sclerite well developed (except *Discotenes*, Genus X, and prepupal larvae of *Piesocorynus*). Ocellus often distinct. Clypeus readily distinguishable from frons. Anterior margin of labrum rounded (except *Phloeobius*, with a shallow emargination). Labrum with four or more than four, pairs of setae. Labral tormae present. Two pairs of peg-shaped sensilla present on epipharynx. Mandible without ventral process. Labium often reduced in size. Labial palpus with one or two articles. Maxillary palpus with two or three articles. Mala with lacinia near middle of inner margin (except *Phloeobius*).

Legs discernible (except *Araecerus*), ranging in development from a very low, rounded projection to legs with two distinct articles.

KEY TO GENERA OF ANTHRIBINAE

1. Abdominal spiracles bicameral (figs. 11, 12) or without air tubes (fig. 9); labial palpus with two articles (except *Euparius* (fig. 14), the only known genus in which a small sclerite is present anteriorly on epipharynx (fig. 45)); (maxillary palpus often with three articles) 4
   Abdominal spiracles unicameral (figs. 10, 13); labial palpus with one article; (maxillary palpus with two articles) 2

2. Thoracic spiracle bicameral; head capsule rounded posterolaterally (as in fig. 18) 3
Thoracic spiracle unicameral; head capsule obviously flattened posterolaterally (as in fig. 16) ..... XX. **Choragus** (p. 514)
3. Abdominal spiracles with air tube elongate and clearly annulated (fig. 10); legs short but distinct (fig. 31); prodorsum on typical abdominal segments not plicate ..... XVIII. **Brachytarsoides** (p. 512)
Abdominal spiracles with air tube short, oval, without annulations (fig. 13); legs absent, each replaced by a cluster of setae (fig. 35); prodorsum on typical abdominal segments plicate ..... XIX. **Araecerus** (p. 513)
4. Labrum with 10 or more than 10 pairs of setae (fig. 46); spiracles of known North American species without air tubes; epipharynx with distinctly more than 7 pairs of setae, including median spines (figs. 48, 50); pronotum with lateral, rodlike thickening; (maxillary palpus with three articles) 5
Labrum with four pairs of setae (as in fig. 44) (except Genus X); spiracles bicameral; epipharynx usually with seven pairs of setae, including median spines (figs. 45, 47, 49, 51); pronotum usually without rodlike thickening; (maxillary palpus with two or three articles) 9
5. Lacinia absent; anterior margin of labrum emarginate; four median spines present on epipharynx; asperities on abdomen abundant, developed as velvety pubescence ..... III. **Phlooebius** (p. 499)
Lacinia present (figs. 39–41); anterior margin of labrum rounded (fig. 46); more than four median spines present on epipharynx (figs. 48, 50); asperities on abdomen sparser, not developed as velvety pubescence 6
6. Median spines of epipharynx moderately numerous to abundant, directed transversely or anteriorly (fig. 48); dorsal surface of mala without tuft of setae 7
Median spines of epipharynx abundant, short, the majority of them directed posteriorly (fig. 50); dorsal surface of mala, immediately above base of lacinia, with a brushlike tuft of setae ..... VII. **Toxonotus** (p. 504)
7. Anterior two-thirds of frons reddish orange ..... IV. **Phoenicobiella** (p. 500)
Pigmentation of frons, if present, confined to a transverse, marginal darkening 8
8. Mala broadly rounded apically (fig. 40); lacinia short, scarcely longer than basal width (European species) ..... V. **Anthribus** (p. 502)
Mala narrower apically (as in fig. 41); lacinia twice as long as basal width (American species) ..... VI. **Neanthribus** (p. 504)
9. Abdominal segment IX with three fleshy protuberances on dorsal surface near posterior margin, one median, and one each side; proventriculus with bands of prominent asperities 10
Abdominal segment IX without fleshy protuberances; proventriculus without asperities 11
10. Maxillary palpus with three articles; legs elongate, with two distinct articles ..... VIII. **Meconemus** (p. 505)
Maxillary palpus with two articles; legs very short, each with one article (fig. 29) ..... IX. **Discotenes** (p. 506)
11. Labrum with nine or ten pairs of setae; eight to ten median spines of epipharynx present ..... X. Genus unknown (p. 506)
Labrum with four pairs of setae; four median spines of epipharynx present 12
12. Head capsule slightly retracted into pronotum, with flattened area on each posterolateral surface, usually broadest before the middle (fig. 16), scarcely pigmented anteriorly, not pigmented posteriorly 13
Head capsule completely free, without such a flattened area, subcircular, broadest at the middle (fig. 18), distinctly and uniformly pigmented throughout 16
13. Maxillary palpus with three articles; (legs distinct, with two articles (fig. 36)) 14
Maxillary palpus with two articles; (legs usually short and indistinct) 15
14. Prementum with one or two pairs of setae; posterior pair of median spines of epipharynx transversely arranged; pronotum with lateral, rodlike thickening ..... XI. Genus unknown (p. 507)
Prementum with four or five pairs of setae; posterior pair of median spines of epipharynx longitudinally arranged; pronotum without lateral rodlike thickening ..... XII. **Piesocorynus** (p. 507)

15. Legs elongate, with two articles; apical article of labial palpus as broad at base as long; anterior pair of median spines of epipharynx situated between the anterior and posterior pairs of peg-shaped sensilla, the posterior pair of median spines longitudinally arranged (fig. 49), XIII. Genus unknown (p. 508)

Legs very short, scarcely discernible; apical article of labial palpus nearly twice as long as broad; anterior and posterior pairs of peg-shaped sensilla close together, situated approximately between the spines of anterior pair of median spines of epipharynx, the posterior pair of spines transversely arranged (fig. 47) ..... XIV. **Ormiscus** (p. 509)

16. Maxillary palpus with three articles; labial palpus with two articles 17

Maxillary palpus with two articles; labial palpus with one article (fig. 14), XVII. **Euparius** (p. 511)

17. Epipharynx with three anterolateral setae; posterior pair of median spines of epipharynx longitudinally arranged; head brown, XV. **Platyrhinus** (p. 510)

Epipharynx with approximately ten anterolateral setae; posterior pair of median spines of epipharynx transversely arranged; head light orange, XVI. **Eurymycter** (p. 511)

III. Genus **Phloeobius** Schoenherr

Phloeobius Schoenherr, Isis von Oken, heft 10, p. 1135, 1823.

Anterior margin of pronotum deeply emarginate, each half of the widely interrupted paired sclerite with its anterior border slightly projecting, brown. Labrum with approximately 10 pairs of setae. Epipharynx with numerous setae anterolaterally, at least two anteromedian setae and four median spines. Lacinia absent. Mala broadly rounded apically. Pronotum with lateral rodlike thickening. All spiracles oval, without air tubes. Asperities developed as patches of velvety pubescence.

Larva moderately large and robust, bluntly wedge-shaped posteriorly, the dorsal surface of abdominal segment IX with two subparallel longitudinal grooves. Body setae numerous, short, slender, inconspicuous. Head pale orange, with flattened area on each posterolateral surface, as broad as long, broadest near the middle, the sides nearly straight and convergent behind the middle. Frontal suture discernible throughout its length. Endocarina present, not deeply pigmented, approximately one-half as long as frons. Anterior one-third of head thickly set with short setae, the setae sparser posteriorly. Ocellus apparently absent. Antenna in a large oval depression. Anterior border of labrum shallowly emarginate. Labral tormae elongate, convergent posteriorly. Numerous short asperities present near the middle of epipharynx. Mandible oblique apically, with large, smooth mola. Labial palpus with two articles, the palpi nearly contiguous at base. Ligula elongate, conical, projecting beyond apex of labial palpi, densely set with short asperities. Prementum with two pairs of very short setae. Premental sclerite not discernible. Submentum with more than ten short to elongate setae. Maxillary palpus with three articles. Stipes with abundant setae dorsally and ventrally. Mala with numerous setae dorsally and ventrally.

Setae on pronotum moderately sparse, short. Legs very short, the two articles vaguely separated, each article bearing several short setae.

Abdominal areas with numerous setae. Anus subterminal.

Width of head: up to 2.3 mm.

P. pilipes Jord. Hoflong, Cachar, Assam, May 13, 1929, ex *Lagerstroemia flos-reginae*, C. F. C. Beeson. Presented by J. C. M. Gardner.

Gardner (1932) describes the larva of *P. pilipes* and also that of *P. gigas* (F.). He states that the larva of *gigas* differs from that of *pilipes* in having the thoracic spiracle bicameral and the abdominal spiracles unicameral, the air tubes minute. In a later paper (1936) he states, indirectly, that the abdominal spiracles are bicameral in the larva of *P. gigas*.

IV. Genus **Phoenicobiella** Cockerell

(Figs. 24, 34, 39)

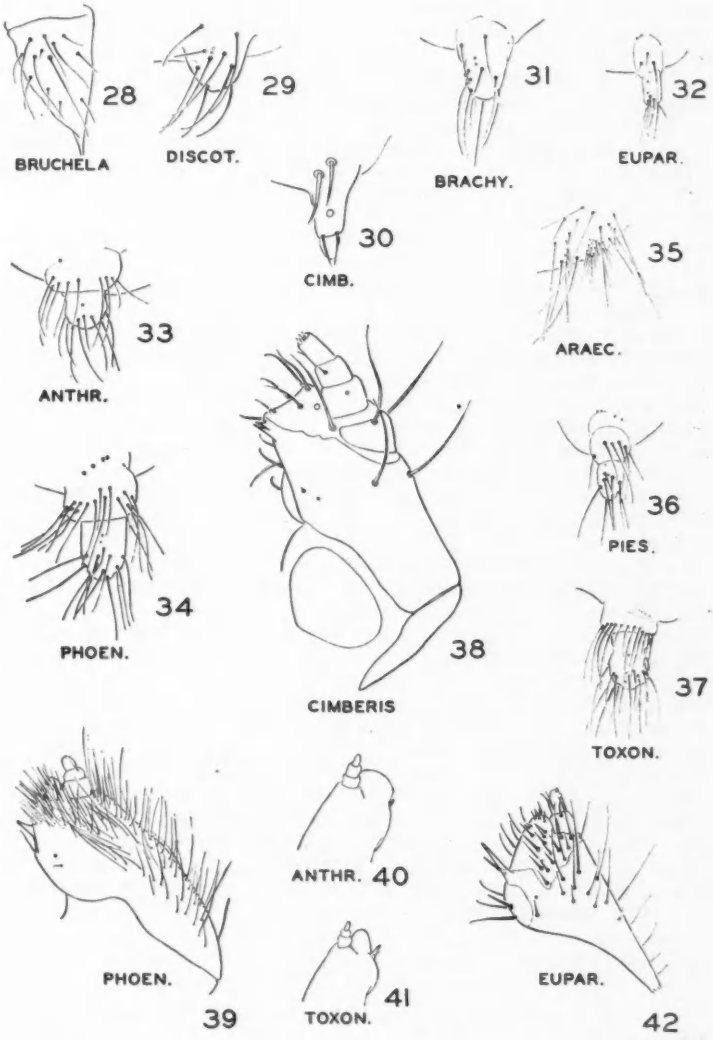
Phoenicobiella Cockerell, Ent. News 17: 243, 1906.

Anterior two-thirds of frons reddish orange, the remainder of head not pigmented. Labrum with 12 to 14 pairs of setae. Twenty to 24 pairs of median spines of epipharynx present, transversely or anteriorly directed. Mandible without projection near middle of dorsal inner margin. Labial palpus with two articles. Maxillary palpus with three articles. Mala rounded apically, dorsal surface without tuft of setae. Lacinia moderately long. Pronotum with lateral, oblique, rodlike thickening. All spiracles oval, without air tubes.

Larva moderately large and robust, thicker anteriorly, bluntly wedge-shaped posteriorly, the dorsal surface of abdominal segment IX with two parallel longitudinal grooves. Pronotum without pigmented sclerite. Body setae numerous, inconspicuous, more abundant ventrally on thoracic segments. Head with flattened area on each posterolateral surface, slightly broader than long, broadest near the middle, the sides nearly straight and convergent behind the middle. Frontal suture distinct throughout its length, nearly straight posteriorly. Endocarina present, nearly one-half as long as frons. Head with numerous short, slender setae. Ocellus not discernible. Antenna very small, not overhung by extension from frons. Labral tormae strong, elongate. Apex of mandible usually obliquely gouge-shaped, mola slightly flattened, nearly smooth. Ligula present. Prementum without sclerite, with two or three pairs of setae. Submentum with several pairs of elongate setae. Stipes and mala with many setae dorsally and ventrally.

EXPLANATION OF PLATE III

Fig. 28. Metathoracic pedal area of *Bruchela lilii*, × 50. Fig. 29. Prothoracic leg of *Discotenes nigrotuberculata*, × 200. Fig. 30. Metathoracic leg of *Cimberis pilosus*, × 325. Fig. 31. Mesothoracic leg of *Brachytarsoides alternatus*, × 100. Fig. 32. Prothoracic leg of *Euparius marmoreus*, × 50. Fig. 33. Same of *Anthribus albinus*, × 75. Fig. 34. Same of *Phoenicobiella chamaeropis*, × 75. Fig. 35. Metathoracic pedal area of *Araecerus fasciculatus*, × 50. Fig. 36. Metathoracic leg of *Piesocorynus* sp., probably *dispar*, × 50. Fig. 37. Prothoracic leg of *Toxonotus fascicularis*, × 75. Fig. 38. Ventral view of left maxilla of *Cimberis pilosus*, × 160. Fig. 39. Same of *Phoenicobiella chamaeropis*, × 50. Fig. 40. Ventral view of right maxilla of *Anthribus albinus*, setae omitted, × 30. Fig. 41. Same of *Toxonotus fascicularis*, × 30. Fig. 42. Ventral view of left maxilla of *Euparius marmoreus*, × 55.


28
BRUCHELA
29
DISCOT.
31
BRACHY.
32
EUPAR.
30
CIMB.
35
ARAEC.
33
ANTHR.
36
PIES.
34
PHOEN.
38
CIMBERIS
37
TOXON.
PHOEN.
39
ANTHR. 40
TOXON.
41
EUPAR.
42

Pronotum very deeply emarginate, nearly divided in the middle, with setae short and sparse. Legs short, clearly biarticulate, with numerous elongate setae, the apical article cylindrical, longer than wide at base.

Setae sparse on dorsal and ventral surfaces of abdomen, more abundant laterally. Asperities not discernible. Anus ventro-terminal.

Width of head: up to 2.3 mm.

P. chamaeropis (Lec.). Savannah, Ga., March 31, 1884, G. Noble. Miami, Fla., April 17, 1918, and March 1, 1919, dead leaf stems of cabbage palmetto, T. E. Snyder.

V. Genus **Anthribus** Geoffroy

(Figs. 21, 33, 40, 48)

Anthribus **Geoffroy, Histoire abregee des insectes qui se trouvent aux environs de Paris, p. 306, 1762.**

Labrum with 11 or 12 pairs of setae. Epipharynx with approximately 25 setae on each side, the median spines transversely or anteriorly directed. Mandible with prominent projection near middle of dorsal inner margin. Maxillary palpus with three articles. Mala very broadly rounded apically, dorsal surface without tuft of setae. Lacinia very short, scarcely longer than wide at base. Pronotum with lateral, oblique, rodlike thickening. All spiracles oval.

Larva moderately large and robust, stouter through thorax, the dorsal surface of abdominal segment IX scarcely flattened, with two indistinct longitudinal grooves. Epipleurum moderately prominent on abdominal segments II, III and IV. Pronotum with lightly pigmented, paired sclerite. Body setae moderately numerous, more conspicuous posteriorly on abdomen and ventrally on thorax. Head uniformly pale orange, approximately as broad as long, broadest at the middle, with flattened area on each posterolateral surface, the sides nearly straight and convergent behind the middle. Frontal suture discernible throughout its length, narrow. Endocarina distinguishable, approximately one-half as long as frons. Head with numerous short, slender setae. Ocellus not discernible. Antenna not overhung by extension from frons. Labral tormae moderately long and strong. Mandible with two apical teeth and subapical dorsal projection; mola with an oblique, transverse ridge. Labial palpus with two articles. Prementum with several elongate setae near base of palpi. Premental sclerite not distinguishable. Submentum with several pairs of moderately long setae. Dorsal surface of maxilla without a transverse band of setae at middle. Stipes with many setae dorsally and ventrally.

EXPLANATION OF PLATE IV

Fig. 43. Lateral view of *Cimberis pilosus*, × 28. Fig. 44. Labrum and clypeus of *Brachytarsoides* sp., near *sticticus* (Fullerton, Md.), × 160. Fig. 45. Epipharynx of *Euparius marmoreus*, × 50. Fig. 46. Labrum and clypeus of *Toxonotus fasciculatus*, × 50. Fig. 47. Epipharynx of *Ormiscus* sp. (Coconut Grove, Fla., in *Tamarindus indica* pod), × 95. Fig. 48. Same of *Anthribus albinus*, × 50. Fig. 49. Same of unknown genus (see p. 508), × 100. Fig. 50. Same of *Toxonotus fasciculatus*, × 50. Fig. 51. Same of *Discotenes nigrotuberculata*, × 115. Fig. 52. Same of *Cimberis pilosus*, × 85.

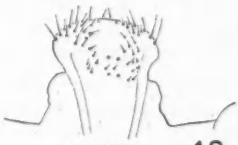
CIMBERIS 43

BRACHY. 44

EUPAR. 45

TOXON. 46

ORMIS. 47



ANTHR. 48

GENUS UNK. 49

TOXON. 50

DISCOT. 51

CIMB. 52

Pronotum emarginate, with setae moderately numerous. Legs short, clearly biarticulate, the apical article of prothoracic leg as broad as long.

Setae more numerous and longer dorsally on posterior abdominal segments. Asperities very fine. Anus ventro-terminal.

Width of head: up to 2.3 mm.

A. albinus (L.). Falster, Denmark, branch of linden. Received from Meinert.

VI. Genus **Neanthribus** Jordan

Neanthribus Jordan, Biologia Centrali-Americana, v. 4, pt. 6, p. 341, 1906.
Pseudanthribus Pierce, U. S. Natl. Mus. Proc. 77 (art. 17): 24, 1930. (New synonymy.) *Anthribus cornutus* Say (Descriptions of New Species of Curculionides of North America, etc., p. 4, 1831, New Harmony, Ind.) is hereby designated as type of *Pseudanthribus* Pierce (l. c.). Adult specimens of *Neanthribus championi* Jordan (l. c., p. 342), type of *Neanthribus* by original designation, have been compared with specimens of *P. cornutus* (Say) and the two species are considered to be congeneric.

Larvae of *Neanthribus* agree with those of *Anthribus* in the important characters which are: Pigmentation of frons confined to a transverse, marginal darkening. Labrum with 10 or more than 10 pairs of setae. Epipharynx with more than seven pairs of setae, the median spines transversely or anteriorly directed. Maxillary palpus with three articles. Dorsal surface of mala without tuft of setae. Pronotum with lateral, oblique, rodlike thickening. All spiracles oval.

Width of head: up to 2.5 mm.

The principal differences which distinguish larvae of *Neanthribus* from those of *Anthribus*, as indicated in the key, are: Mala narrower apically. Lacinia twice as long as wide at base.

Neanthribus sp. Venice, La., February 19, 1945, in Virginia creeper (*Psedera*) vine, H. A. McPherson. Boothville, La., February 21, 1945, in Virginia creeper vines, D. W. Whitmire.

Neanthribus sp. Mexico, January 16, 1946, stem *Merostachys racemiflora*, G. F. Callaghan, E. D. Algert, and P. X. Peltier.

VII. Genus **Toxonotus** Lacordaire

(Figs. 9, 37, 41, 46, 50)

Toxonotus Lacordaire, Histoire naturelle des insectes. Genera des Coléoptères, Paris, v. 7, p. 575, 1866.

Labrum with approximately 20 pairs of setae. Epipharynx with approximately 40 setae on each side, the median spines short, the majority of them directed backwards. Mandible without strong projection on dorsal inner margin, the mola without oblique ridge. Maxillary palpus with three articles. Mala less broadly rounded than in *Anthribus*. Lacinia twice as long as broad at base. Dorsal surface of mala, immediately above base of lacinia, with a brushlike tuft of setae.

Width of head: 2.0 mm.

T. fascicularis (Schoen.). Big Pine, Fla., 1919, dead twig *Rhacoma crossopetalum*, Schwarz and Barber. Big Pine Key, Fla., April 6, 1945, dead limb *Coccoloba floridana*, O. B. Link.

VIII. Genus **Meconemus** Imhoff

Meconemus Imhoff, (Labram, David, and Imhoff, Ludwig) Singulorum Generum Curculionidum, Basel, No. 42, 1842.

Labrum with four pairs of setae. Epipharynx with seven pairs of setae. Labial palpus with two articles. Maxillary palpus with three articles. Mala rounded, with numerous setae. Lacinia very short, acute. Pronotum with lateral, rodlike thickening. All spiracles bicameral, the air tubes very short. Legs elongate, with two distinct articles. Ninth abdominal segment with three small, flattened, fleshy protuberances on dorsal surface, near posterior margin, one median and one each side. Proventriculus with bands of prominent asperities.

Larva moderately large and robust, slightly thicker anteriorly. Paired sclerite of pronotum very lightly pigmented, remainder of body white. Body setae numerous, more conspicuous ventrally on thoracic segments. Head not pigmented except for small, triangular, pigmented area anteriorly on frons, with flattened area on each posterolateral surface, as broad as long, broadest near the middle, the sides nearly straight and convergent behind the middle. Frontal suture hardly discernible. Endocarina not heavily pigmented, more than one-half as long as frons. Head with moderately numerous short to moderately long setae. Ocellus small, indistinct. Antenna not overhung by extension from frons. Labral tormae short, stout. Posterior pair of median spines of epipharynx transversely arranged. Mandible apically bifid, with strong, rounded mola. Labial palpus with two articles, the basal article distinct, the two palpi nearly contiguous at base. Prementum with one pair of elongate setae. Premental sclerite present. Submentum with approximately eight pairs of setae.

Pronotum emarginate, nearly divided in the middle line, with setae short and sparse. Air tubes of thoracic spiracle without annulations, the air tubes very short, scarcely extending beyond margin of peritreme.

Air tubes of abdominal spiracles very short, without annulations. Asperities hardly discernible except a transverse band of strong asperities ventrally on abdominal segment IX.

Width of head: up to 2.5 mm.

M. infuscatus (Fåhr.). Nicholson, Miss., December 26, 1944, dry branch *Liquidambar*, L. V. France. Nicholson, Miss., January 25, 1945, dry wood *Halesia carolina*, G. J. Rau. Nicholson, Miss., February 10, 1945, dead limb *Carpinus* on ground, M. Gordon.

The identification of these larvae as *Meconemus* is inferred from their size and the locality at which they were collected. The other genera occurring in Mississippi and containing species as large as this are already known.

A proventriculus similar to that reported by Gardner (1936) for a larva of *Autotropis* Jordan is present in larvae of the above-described species. Gardner also reports that the ninth abdominal segment of the larva of *Autotropis* bears a rounded, fleshy protuberance at each posterior angle, a condition very suggestive of that here noted for *Meconemus* and *Discotenes*. It seems quite likely, therefore, that these three genera are closely related.

IX. Genus **Discotenes** Imhoff

(Figs. 15, 20, 29, 51)

Discotenes Imhoff, (Labram, David, and Imhoff, Ludwig) Singulorum Generum Curculionidum, Basel, No. 51, 1841.

Dorsal surface of abdominal segment IX with three flattened fleshy protuberances near posterior margin, one median and one each side. Labrum with four pairs of setae. Head capsule with flattened area on each posterolateral surface. Hypopharyngeal sclerite absent. Maxillary palpus with two articles. All spiracles small, bicameral. Legs very short, each with one article. Proventriculus with bands of prominent asperities.

Larva small, moderately robust anteriorly, bluntly wedge-shaped posteriorly. Body without pigmented sclerites. Body setae numerous, more conspicuous ventrally and posteriorly. Head scarcely pigmented, slightly longer than broad, broadest slightly before the middle, the sides nearly straight and convergent behind the middle. Frontal suture indistinguishable posteriorly, indistinct anteriorly. Endocarina absent. Head with moderately numerous short, slender setae. Antenna not overhung by extension from frons. Labral tormae colorless, elongate. Epipharynx with four anterolateral and four anteromedian setae and four median spines, the posterior pair of spines transversely arranged; a few asperities near middle of epipharynx. Mandible gouge-shaped apically, without distinguishable mola. Labial palpus with two articles, basal article short, indistinct, without discernible seta, the palpi moderately widely separated. Prementum with three pairs of elongate setae. Premental sclerite absent. Submentum with approximately 10 pairs of setae on the median area. Stipes and mala with moderately numerous setae dorsally and ventrally; mala bluntly pointed.

Pronotum gradually but distinctly emarginate, with vague lateral rodlike thickening and with setae rather short and sparse. Air tubes of thoracic spiracle without annulations, the length of each distinctly less than greatest diameter of broadly oval peritreme.

Air tubes of abdominal spiracles without annulations, the length of each less than the diameter of subcircular peritreme.

Width of head: up to 0.68 mm.

D. nigrotuberculata (Schffr.). Brownsville, Tex., in *Acacia*, Hopkins, U. S. No. 10631d.

X. Genus unknown

Head slightly longer than broad, with flattened area on each posterolateral surface. Hypopharyngeal sclerite hardly discernible, not projecting. Labrum with approximately 10 pairs of setae. Labral tormae stout, subtriangular. Epipharynx with three anterolateral and four anteromedian setae, and 8 to 10 median spines. Epipharynx with longitudinal, subparallel patches of asperities near middle. Labial palpus with two articles, the basal article with a distinct seta. Prementum with approximately 10 setae. Maxillary palpus with three articles. Stipes with numerous setae dorsally and ventrally. Lacinia stout. Mala pointed, with moderately numerous setae dorsally and

ventrally. Pronotum without lateral, rodlike thickening. All spiracles bicameral. Legs clearly biarticulate.

Width of head: up to 1.05 mm.

College Park, Md., October 18, 1942, bark of dead oak, W. H. Anderson.

XI. Genus unknown

Head as broad as long, with flattened area on each posterolateral surface. Hypopharyngeal sclerite very stout, the anterior margin straight. Labrum with four pairs of setae. Labral tormae rather short, slender, subtriangular. Epipharynx with three anterolateral and four anteromedian setae and four median spines. Both pairs of median spines transversely arranged. Epipharynx with central patch of moderately distinct asperities. Labial palpus with two articles, the basal article with numerous short, slender asperities apically. Prementum with one pair of elongate setae and numerous short, slender asperities. Mentum and submentum vaguely distinguishable. Submentum with several pairs of setae. Maxillary palpus with three articles. Lacinia stout. Mala apically acute and with moderately numerous setae dorsally and ventrally.

Thoracic spiracle bicameral, the air tubes indistinctly annulated. Legs clearly biarticulate.

Abdominal spiracles bicameral, the length of each air tube subequal to diameter of subcircular peritreme, the air tubes with a few indistinct annulations. Asperities more distinct in two patches, one above, the other below the spiracle on abdominal segments I to IV.

Width of head: up to 1.0 mm.

Mount Pleasant, S. C., August 8, 1944, dead wood of *Ficus*, M. J. Mallia. Nicholson, Miss., January 30, 1945, dry sprout *Persea* sp., M. Gordon. Picayune, Miss., December 29, 1944, dry pecan branch, H. A. McPherson and L. V. France.

A larva of approximately the same size and related to the larvae described above is in the collection: Mexico, December 21, 1937, dry mesquite wood. It differs in several features, the most important being epipharynx with approximately 15 anterolateral setae and the apex of prothoracic leg modified. The modification of the leg suggests the condition, described by Gardner (1936), found in larvae of *Tropideres*. The latter genus does not occur in the United States (Wolfrum, 1938). It is replaced by *Goniocloeous* Jordan.

XII. Genus **Piesocorynus** Dejean

(Figs. 6, 7, 12, 16, 36)

Piesocorynus Dejean, Catalogue des Coléoptères, ed. 3, p. 257, 1837.

Head with a flattened area on each posterolateral surface. Labrum with four pairs of setae. Epipharynx with four median spines. Posterior pair of median spines longitudinally arranged. Labial palpus with two articles. Prementum with four or five pairs of setae. Maxillary palpus with three articles. Mala subacute apically. Anterior margin of pronotum not emarginate. Pronotum without lateral, rodlike thickening. All spiracles bicameral. Legs elongate, clearly

biarticulate. Anus ventro-terminal. Abdominal segment IX usually with several strong, hook-shaped asperities on each side of eusternum.

Larva moderately large, robust, bluntly wedge-shaped posteriorly. Body setae moderately numerous, inconspicuous except dorsally on abdominal segments VI to VIII and ventrally on thorax. Head as long as or slightly longer than broad, broadest clearly before the middle, the sides nearly straight and convergent behind the middle. Frontal suture distinguishable throughout its length. Endocarina indistinct, short. Head with moderately numerous, short to moderately long setae. Ocellus indistinct. Antenna small, scarcely overhung by extension from frons. Labral tormae moderately stout and long. Epipharynx with three anterolateral and four anteromedian setae, and with subparallel, longitudinal patches of slender asperities near the middle. Mandible with indistinct, flattened, smooth mola. Submentum with several pairs of setae. Stipes and mala with moderately numerous setae dorsally and ventrally.

Pronotum with moderately numerous setae. Air tubes of thoracic spiracle slender, with annulations, the length of each less than one-third the greatest diameter of broadly oval peritreme.

Length of each air tube of abdominal spiracles approximately one-third the diameter of subcircular peritreme. Setae numerous on abdominal areas.

Width of head: up to 1.7 mm.

P. mixtus Lec. University Park, Md., winter 1944–45, in fungus, *Nummularia tinctor*, growing in bark of dead maple, W. H. Anderson. The mature larvae excavate pupal cells between the bark and the wood in the fall and transform to prepupal larvae which overwinter. Adults appear in April or May.

Piesocorynus sp., probably *dispar* (Gyll.). Data as above. Mature larvae excavate pupal cells in the wood, plugging the hole with wood fibers. Adults of *dispar* were collected on the fungus but none was reared.

Piesocorynus sp. College Park, Md., October 18, 1942, bark of dead oak, W. H. Anderson.

Piesocorynus sp. Nicholson, Miss., December 12, 1944, oak stump, A. L. Williamson. Nicholson, Miss., January 13, 1945, dead limb of red oak, H. A. McPherson. Nicholson, Miss., January 22, 1945, rotting stump *Carpinus caroliniana*, G. J. Rau. Picayune, Miss., December 16, 1944, dead, dry oak wood, A. L. Williamson and L. V. France.

XIII. Genus unknown

(Fig. 49)

Head as long as broad, with flattened area on each posterolateral surface. Hypopharyngeal sclerite well developed. Labrum with four pairs of setae. Labral tormae long, slender. Epipharynx with three anterolateral and four anteromedian setae and four median spines. Posterior pair of epipharyngeal spines longitudinally arranged. One pair of peg-shaped sensilla in front of, the other behind the anterior pair of spines. A few slender asperities arranged in two longitudinal, subparallel patches near middle of epipharynx. Labial palpus with

two short articles, the apical article as broad as long, the basal article with a seta. Prementum with two pairs of setae. Submentum with one or two pairs of setae on median area, each lateral area with approximately five setae. Maxillary palpus with two articles. Stipes with moderately numerous setae dorsally and ventrally. Lacinia stout. Mala acute, with moderately numerous setae.

Anterior margin of pronotum not emarginate. Thoracic spiracle bicameral, the air tubes slender, each nearly as long as greatest diameter of broadly oval peritreme, with numerous annulations. Legs clearly biarticulate.

Abdominal spiracles bicameral. Abdominal segment IX without fleshy protuberances.

Width of head: up to 0.9 mm.

University Park, Md., August 27, 1944, in fungus, *Nummularia tinctor* on dead maple, W. H. Anderson. It is possible that the larvae described above belong to the genus *Eusphyrus* Leconte (1876, p. 399).

XIV. Genus **Ormiscus** Waterhouse

(Figs. 27, 47)

Ormiscus Waterhouse, Ann. and Mag. Nat. Hist. 16: 37, 1845.

Head with flattened area on each posterolateral surface. Hypopharyngeal sclerite strong. Labrum with four pairs of setae. Anterior and posterior pairs of peg-shaped sensilla on epipharynx usually close together, situated approximately between the spines of anterior pair of median spines, the posterior pair of spines transversely arranged. Labial palpus with two articles, the apical article nearly twice as long as width at base. Submentum with one pair of setae on median area. Maxillary palpus with two articles. Legs very short, often hardly discernible. Abdominal segment IX without fleshy protuberances.

Larva small, moderately slender, of nearly equal thickness throughout, not wedge-shaped posteriorly. Anterior margin of pronotum straight, the pronotum as long in the middorsal line as it is laterally. Body without pigmented areas. Body setae numerous, rather conspicuous ventrally and posteriorly. Head only very lightly pigmented, slightly longer than broad, broadest near the middle, the sides nearly straight and convergent behind the middle. Frontal suture indistinct but visible throughout its length. Endocarina present, colorless, approximately one-third as long as frons. Head with moderately numerous, moderately long to long setae on anterior half, posterior half without setae. Antenna somewhat overhung by extension from frons. Labral tormae moderately long and slender. Epipharynx with three anterolateral and four anteromedian setae, and usually with a few hardly discernible asperities. Mandible with two apical teeth, the mola narrow, smooth. Basal article of labial palpus without discernible seta but with slender apical asperities. Premental sclerite present, narrowly interrupted in the middle. Prementum with one pair of elongate setae. Stipes with more than 10 setae dorsally and ventrally. Mala apically pointed, with moderately numerous setae dorsally and ventrally.

Pronotum with numerous setae. Thoracic spiracle bicameral, the air tubes without annulations, the length of each approximately one-half that of the greatest diameter of broadly oval to subcircular peritreme.

Prodorsum of typical abdominal segments with a short, transverse ampullalike protuberance, usually somewhat more prominent on segments IV and V. Abdominal spiracles bicameral, the air tubes without annulations, the length of each air tube usually nearly as great as the greatest diameter of broadly oval to subcircular peritreme. Abdominal areas with numerous setae. Asperities hardly discernible. Anus terminal.

Width of head: up to 0.76 mm.

Description based upon numerous larvae which represent several species, only one of which has been identified, namely, *O. angulatus* (Suffr.): Santiago de las Vegas, Cuba, March, 1905, in husk, immediately about the seeds of *Artocarpus communis*, G. Dimmock. The unidentified larvae, mainly from the Southeastern States, were collected in various hosts, nearly always in dead twigs.

Ormiscus angulatus was originally described by Suffrian (1870, p. 187) in the genus ***Tropideres*** Schoenherr (1823, p. 1135). It was transferred to ***Ormiscus*** by Wolfrum (1930). If this generic assignment is correct and no specific synonymy is involved, the species ***Ormiscus angulatus*** Pierce (1930, p. 6) is without a name.

XV. Genus **Platyrhinus** Clairville

***Platyrhinus Clairville*, Entomologie Helvetique ou Catalogue des Insectes de la Suisse (plates by J. R. Schellenberg), Zurich, p. 112, 1798.**

Head without flattened area on each posterolateral surface, the sides rounded behind the middle. Labrum with four pairs of setae. Epipharynx with three anterolateral setae. Posterior pair of median spines of epipharynx longitudinally arranged. Labial palpus with two articles. Maxillary palpus with three articles. All spiracles bicameral, the air tubes very short, the peritreme broadly oval.

Larva large, robust, tapering posteriorly, strongly curved through abdominal segments V and VI. Anterior margin of pronotum not emarginate. Paired sclerite of pronotum light brown. Body setae moderately numerous, more conspicuous ventrally on thoracic segments. Head brown, slightly broader than long, broadest at the middle, rounded posteriorly. Frontal suture distinct throughout its length, angulate posteriorly. Endocarina present, less than one-half as long as frons. Setae on head moderately numerous. Ocellus distinct. Antenna nearly completely overhung by extension from frons. Labral tormae moderately long, stout. Epipharynx without sclerite anteromedially, with four anteromedian setae. Mandible with two apical teeth. Outer surface of mandible with two setae. Mola large, rounded, smooth. Labium moderately small. Prementum with one pair of setae. Premental sclerite present. Submentum with several pairs of setae. Stipes and mala with moderately numerous setae dorsally and ventrally; mala bluntly pointed apically.

Pronotum with setae moderately numerous. Legs clearly biarticulate, the apical article bluntly conical, each article with elongate setae near apex.

Setae on abdominal areas moderately numerous. Anus terminal. Asperities inconspicuous, sparse.

Width of head: up to 3.0 mm.

P. resinosus (Scop.). Sjaelland, Denmark, in dead beech, Meinert. Sjaelland, Denmark, August 5, 1906, in black fungus on beech, E. Rosenberg. (This latter lot is identified as *P. latirostris* (F.), a synonym of *P. resinosus*.)

XVI. Genus **Eurymycter** Leconte

Eurymycter Leconte, Amer. Phil. Soc. Proc. 15 (96): 394, 1876.

Head light orange, smoothly rounded laterally, without flattened areas. Labrum with four pairs of setae. Epipharynx with approximately 10 anterolateral setae. Posterior pair of median spines of epipharynx transversely arranged. Labial palpus with two articles. Maxillary palpus with three articles. All spiracles bicameral. Air tubes of thoracic spiracle very short, the length of each about one-half as great as the diameter of peritreme.

Larva moderately large, moderately robust, slightly wedge-shaped through abdominal segment IX, the dorsal surface of abdominal segment IX with two parallel, longitudinal grooves. Anterior margin of pronotum straight. Paired sclerite of pronotum light orange. Body setae moderately numerous. Head as broad as long, broadest at the middle, oval posteriorly. Frontal suture indistinct posteriorly. Endocarina present, not pigmented, less than one-half as long as frons. Head with numerous short to moderately long setae. Ocellus moderately prominent. Antenna nearly overhung by extension from frons. Labral tormae short to moderately long. Epipharynx with four anteromedian setae, without asperities. Mandible with two apical teeth, the mola straight, narrow, smooth. Outer surface of mandible with at least four setae. Labium small. Prementum with one pair of setae. Premental sclerite short, interrupted in the middle line. Submentum with several pairs of setae. Stipes with several setae dorsally and ventrally. Mala pointed, with moderately numerous setae dorsally and ventrally.

Pronotum with numerous setae. Legs clearly biarticulate, the apical article bluntly attenuate, each article with several elongate setae.

Anus ventro-terminal. Asperities abundant and moderately conspicuous, at least dorsally.

Width of head: up to 2.2 mm.

E. fasciatus (Oliv.). Plummers Island, Md., February 10, 1910, in old sycamore log in gallery below knob of hard black fungus on surface, H. S. Barber. Adults were not reared but association of adults of *fasciatus* with the same kind of fungus leads to the belief that the identification of the larvae is correct. Data on adult specimens of this species, without associated larvae, indicate that *Sassafras* and *Betula* also may serve as hosts.

XVII. Genus **Euparius** Schoenherr

(Figs. 11, 14, 18, 25, 32, 42, 45)

Euparius Schoenherr, Isis von Oken, heft 10, p. 1135, 1823.

Head uniformly reddish brown, subcircular, without flattened areas. Labrum with four pairs of setae. Posterior pair of median spines of epipharynx arranged longitudinally. Epipharynx with small sclerite between and in front of anterior pair of median spines. Labial palpus

with one article. Maxillary palpus with two articles. All spiracles bicameral, the length of each air tube of the abdominal spiracles usually less than the diameter of subcircular peritreme.

Larva moderately large, rather slender, of nearly equal thickness throughout, bluntly wedge-shaped posteriorly. Pronotum with paired brownish-yellow sclerite. Body setae moderately numerous. Head as broad as or broader than long. Frontal suture narrow, distinct throughout its length, incomplete, but ending laterad of antenna. Endocarina absent. Head with numerous short to moderately long setae arranged in vague rows at least posterolaterally. Ocellus prominent. Antenna scarcely overhung by extension from frons. Labral tormae stout, moderately long. Epipharynx with three anterolateral and four anteromedian setae. Mandible with two apical teeth and moderately prominent projection near middle of dorsal inner margin. Mandibular mola narrow, straight, without transverse grooves. Outer surface of mandible with five setae. Labium small, the palpi touching at base, each palpus directed slightly dorsally. Prementum narrow, with a single elongate seta on each side. Premental sclerite distinct. Submentum with several pairs of elongate setae. Stipes and mala with moderately numerous setae dorsally and ventrally, mala acute apically.

Pronotum with numerous setae. Air tubes of thoracic spiracle extending from posterior margin of peritreme, each air tube shorter than diameter of oval peritreme, indistinctly annulated. Legs moderately long, with two articles, each article with several elongate setae.

Abdominal areas with numerous setae. Anus terminal. Asperities moderately conspicuous along anterior margin of dorsal body folds.

Width of head: up to 1.6 mm.

The first-stage larva agrees with the description given above in the principal characters. It differs in that the head is lighter in color; the sclerite is not discernible on epipharynx; the diameter of peritreme is much shorter than the length of the air tubes; the mandible bears only two setae. An egg-tooth is present immediately above the spiracle on abdominal segments I to III.

E. marmoreus (Oliv.). Numerous larvae from various localities in the Southeastern States. The larvae are from a variety of woody plants but probably always associated with fungus.

XVIII. Genus **Brachytarsoides** Pierce

(Figs. 3, 4, 10, 31, 44)

Brachytarsoides Pierce, U. S. Natl. Mus. Proc. 77 (art. 17): 29, 1930.

Prodorsum not prominent on abdominal segments and not plicate. Head scarcely pigmented, without flattened areas. Labial palpus with one article. Maxillary palpus with two articles. Thoracic spiracle bicameral, abdominal spiracles unicameral, the air tubes distinctly annulated.

Larva small, moderately slender. Pronotum without pigmented sclerite. Body setae moderately numerous. Head as broad as or slightly broader than long, broadest at the middle, rounded posteriorly. Frontal suture indistinct. Endocarina absent. Head with moderately numerous short to moderately long setae. Ocellus prominent. Antenna

not overhung by extension from frons. Labrum with four pairs of setae. Labral tormae stout, moderately long. Epipharynx with two or three anterolateral and four anteromedian setae and four median spines; without asperities. Mandible with two apical teeth and with rounded, transversely grooved mola. Labium small, the palpi close together. Prementum narrow, with one or with five or six pairs of setae. Premental sclerite complete. Submentum with two or more pairs of elongate setae. Stipes and mala with several setae dorsally and ventrally. Apex of mala usually with a short, membranous projection which bears setae.

Pronotum with numerous setae. Length of each air tube of thoracic spiracle subequal to or less than greatest diameter of broadly oval peritreme. Legs short, usually with two indistinctly separated articles, each article bearing elongate setae.

Length of air tube of abdominal spiracles subequal to or slightly greater than diameter of broadly oval to subcircular peritreme. Abdominal areas with numerous setae, the setae sparser on pleural, pedal and eusternal areas than dorsally. Anus terminal. Asperities absent or inconspicuous.

Width of head: up to 0.93 mm.

B. alternatus (Say). Vienna, Va., June 24, 1943, in fungus, *Cystopus*, on *Ipomaea*, J. C. Bridwell.

B. sticticus (Boh.). Victoria, Tex., in nuts, J. C. Bridwell.

Brachytarsoides sp., near *sticticus* (Boh.). Fullerton, Md., September 22, 1943, in smut on corn, Mohr and Graham.

B. limbatus (Say). Dallas, Tex., August 16, 1906, in stems *Sideranthus*, W. D. Pierce.

Brachytarsoides sp., near *limbatus* (Say). Burlington, Ore., August 18, 1944, in flower heads of *Helenium autumnale*, E. I. Smith, G. F. Prole and C. G. Anderson.

Brachytarsoides sp., probably *vestitus* (Lec.). Columbus, Tex., from *Helenium microcephalum*, Hunter Note No. W-122 I-1.

XIX. Genus **Araecerus** Schoenherr

(Figs. 13, 23, 26, 35)

Araecerus Schoenherr, Isis von Oken, heft 10, p. 1135, 1823.

Prodorsum on abdominal segments I to V prominent, with a transverse row of short, longitudinal plicae. Head light yellow, without flattened areas. Labial palpus with one article. Maxillary palpus with two articles. Thoracic spiracle bicameral, abdominal spiracles unicameral, the air tubes short, without annulations. Legs absent, replaced by clusters of setae.

Larva moderately small, moderately slender, tapering slightly anteriorly. Pronotum without pigmented sclerite. Body setae numerous, particularly on ventral surface of thoracic segments. Head as broad as or slightly broader than long, broadest near the middle, rounded posteriorly. Frontal suture distinguishable throughout its length, indistinctly complete anteriorly. Endocarina absent. Head with numerous short to moderately long setae. Ocellus prominent. Antenna somewhat overhung by extension from frons. Labrum with four pairs of setae. Labral tormae moderately long. Epipharynx

with three anterolateral and four anteromedian setae and four median spines; without asperities. Mandible with two apical teeth, the dorsal tooth shorter and with projection near base. Mandible with nearly straight, flattened mola. Labium small, each labial palpus with a seta near base on inner surface. Prementum narrow, with two pairs of moderately long setae, and with asperities laterally. Premental sclerite interrupted in the middle. Submentum indistinctly set off from mentum, with several pairs of setae. Stipes and mala with numerous setae dorsally and ventrally.

Pronotum with numerous setae. Peritreme of thoracic spiracle broadly oval.

Peritreme of abdominal spiracles subcircular. Abdominal areas with numerous setae. Anus terminal. Asperities short, colorless, pointed.

Width of head: up to 0.95 mm.

A. fasciculatus (Deg.), the coffee-bean weevil. This species is cosmopolitan in distribution and has been collected from a wide variety of hosts.

XX. Genus **Choragus** Kirby

Choragus Kirby, Linn. Soc. London, Trans. 12: 447, 1818.

Prodorsum of typical abdominal segments normal. Head with flattened area on each posterolateral surface. Labial palpus with one slender article. Maxillary palpus with two articles. Pronotum without lateral, rodlike thickening. All spiracles unicameral. Anus terminal.

Larva small, moderately robust, not wedge-shaped posteriorly. Anterior margin of pronotum transverse. Body without pigmented areas. Body setae moderately numerous, longer on ventral surface of thorax. Head scarcely pigmented, as broad as long, broadest at the middle, the sides nearly straight and convergent behind the middle. Frontal suture not discernible posteriorly, vague anteriorly. Endocarina indistinct, nearly one-half as long as frons. Antenna somewhat overhung by extension from frons. Labrum with four pairs of setae. Labral tormae moderately long, only slightly pigmented. Epipharynx with three anterolateral and four anteromedian setae and four median spines, both pairs of spines transversely arranged. Epipharynx without asperities. Mandible with two apical teeth, the mola strong. Labial palpus without discernible seta. Premental sclerite absent or developed only laterally. Prementum with one pair of elongate setae. Submentum with four or more than four pairs of setae. Stipes with a total of approximately 15 setae dorsally and ventrally. Mala pointed apically, with moderately numerous setae dorsally and ventrally.

Pronotum with setae rather sparse and fine. Air tube of thoracic spiracle without annulations, the length of the air tube as great as the diameter of subcircular peritreme. Legs vestigial, each consisting of a very low, rounded projection which bears three elongate setae.

Air tube of abdominal spiracles without annulations, its length subequal to diameter of subcircular peritreme. Abdominal areas with the setae sparse. Asperities not discernible.

Width of head: up to 0.47 mm.

C. zimmermanni Lec. University Park, Md., January 30, 1944, associated with the fungus *Rosellinia purpureo-fusca* (Schw.) Ell. & Ev., on fallen dead maple branch, W. H. Anderson. University Park, Md., March 18, 1945, associated with the same fungus on fallen dead oak branch. The larvae overwinter in the wood, pupating in the early spring. Adults begin to emerge the latter part of April. Larvae of this or a closely related species were taken at Picayune, Miss., December 14, 1944, in dead wood of *Quercus nigra*, L. V. France.

From Gardner's description (1936), as ?*Tropideres paviei* (Lesne) and (1937), it is apparent that the larva of *Deropygus curvatus* Jord. is related to that of *Choragus*.

Subfamily **Cimberinae**[6]

XXI. Genus **Cimberis** Gozis

(Figs. 2, 8, 17, 22, 30, 38, 43, 52)

Cimberis Gozis, Soc. Ent. de France Bul. (6) 1: cxii, 1881.

Head free. Clypeus not distinguishable from frons. Epipharynx with one pair of peg-shaped sensilla. Mandible with low ventral process. Labial palpus with two articles. Maxillary mala subquadrate, the apical margin nearly straight.

Larva small, moderately slender, of nearly equal thickness throughout. Anterior margin of pronotum transverse. Pronotum with lightly pigmented sclerite. Body setae numerous, as conspicuous dorsally as ventrally. Head orange, broader than long, broadest behind the middle, only slightly rounded posteriorly, without flattened areas. Frontal suture distinct throughout its length, not obviously complete anteriorly. Endocarina present, nearly one-half as long as frons. Hypopharyngeal sclerite well developed. Ocellus moderately prominent. Antenna almost completely overhung by extension from frons, one of the minute processes peg-shaped. Labrum incompletely set off from clypeus. Anterior margin of labrum only slightly rounded. Labrum with four pairs of setae. Labral tormae absent. Epipharynx with two anterolateral and two anteromedian setae and four median spines, the median spines very short, the pairs well separated, the spines of posterior pair longitudinally arranged. Epipharynx without anteromedian pair of sensilla, without asperities. Mandible with two apical teeth, the mola triangular in surface view, moderately prominent. Prementum with one pair of elongate setae. Premental sclerite interrupted in the middle. Submentum with three pairs of setae. Stipes with two setae. Maxillary palpiger present, bearing three setae. Inner margin of mala, slightly behind angulate inner corner, with colorless, straight lacinia. Mala with moderately numerous setae dorsally and ventrally.

Setae on pronotum moderately numerous. Thoracic spiracle in mesothorax, the spiracle bicameral, the air tubes with numerous annula-

[6]This name, as well as the generic name *Cimberis*, is used here provisionally. The correct generic name for the species described by Leconte (1876, p. 2) as *Rhinomacer pilosus* is uncertain. It is apparent, however, that it does not belong in the genus *Rhinomacer* Fabricius (Species Insectorum, v. 1, p. 199, 1781), which is a monobasic genus having *curculioides* F. as type. The latter species is placed in the Pythidae.

tions, the length of each air tube subequal to or slightly greater than diameter of subcircular peritreme. Legs very small, conical or subconical.

Abdominal spiracles bicameral, the air tubes with annulations, the length of each air tube greater than the diameter of subcircular peritreme. Setae moderately numerous on abdominal areas. Anus terminal. Asperities inconspicuous and moderately sparse laterally and ventrally, not discernible dorsally.

Width of head: up to 0.67 mm.

The first-stage larva agrees with the description of the mature larva in the principal characters. It differs in that the maxillary palpiger is not distinguishable and the legs are blunt and do not bear setae. Short, conical, sclerotized egg-teeth are present laterally on mesothorax and metathorax and immediately above the spiracle on abdominal segments I to VIII.

C. pilosus (Lec.). Clifton, Va., May 9, 1933, from male cones of *Pinus virginiana*, J. C. Bridwell. Pupation takes place in trash on the ground.

The reasons for transferring the larva of *Cimberis* from the Curculionidae to the Anthribidae were pointed out by Emden (1938). The correctness of this transfer has been further substantiated by Ting (1940), who has studied the adults of this and related genera. Crowson (1944) believes that *Cimberis* and its relatives deserve family rank ((Nemonychidae) = Doydirhynchidae). On the basis of the characters of the larvae which are at present considered diagnostic for the Anthribidae, it is more satisfactory to retain the group as a part of the latter family.

A larva which is closely related to that of *Cimberis* is in the collection and has been studied. It was collected on *Fascicularia bicolor* from Chile, February 1, 1936. It differs from the larva of *Cimberis* in several ways: Labrum is clearly distinct from clypeus; labral tormae are present, although short; epipharynx has three anterolateral and four anteromedian setae; premental sclerite is not interrupted; maxillary palpiger is not distinguishable. No known records of species from Chile, which are closely related to *Cimberis*, have been encountered so it is impracticable to attempt any speculation in regard to the identity of this larva.

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A CATALOGUE OF THE HESPERIOIDEA OF VENEZUELA, by E. L. Bell. Boletin de Entomologia Venezolana V, pp. 65–203, 1946.

So many species of South and Central American species of Hesperioidea have been described in the past few decades without the publication of adequate synoptic studies of the group that any effort to bring together comprehensive data for geographic areas or for taxonomic divisions must be regarded as a valuable and badly needed contribution. No one in North America is better qualified to do such work than Mr. Bell, who has already collaborated with Kenneth J. Hayward in Argentina, a leading South American authority, on a catalogue of the fauna of Ecuador.

The author apologizes for the many typographic errors in this publication, which are due to his having been given no opportunity to read the proof. He has prepared a mimeographed list of corrections. While such matters are a source of inconvenience, they can in no way reflect on the value of this catalogue. It lists all species originally described from Venezuela or later recorded from that country, and those represented by specimens bearing Venezuelan labels in the Collections of the American Museum of Natural History, The Academy of Natural Sciences in Philadelphia and the United States National Museum. Some records from the collection of Mr. René Lichy are also included. Indefinite records embracing the area, such as "Mexico to south Brazil," are omitted.

The catalogue lists genera with the genotype, the original reference and those of synonyms, and brief notes on generic characters. Species are listed with synonymy, distribution, and a short bibliography including references to principal works and to shorter papers which include figures. In each case a note indicates the location of figures of the insect or the genitalia. The catalogue also includes a bibliography and an index to scientific names—A. W. L.

THE PROVENTRICULUS OF MACROBASIS UNICOLOR KIRBY
(Coleoptera: Melodiae)[1]

WILLIAM W. JUDD
McMaster University,
Hamilton, Ontario

The proventriculus of *Epicauta cinerea marginata* Fabr. (Meloidae) was described by Everly (1936). The descriptive terms employed by him are used as far as possible in the following description of the proventriculus of *Macrobasis unicolor* Kirby.

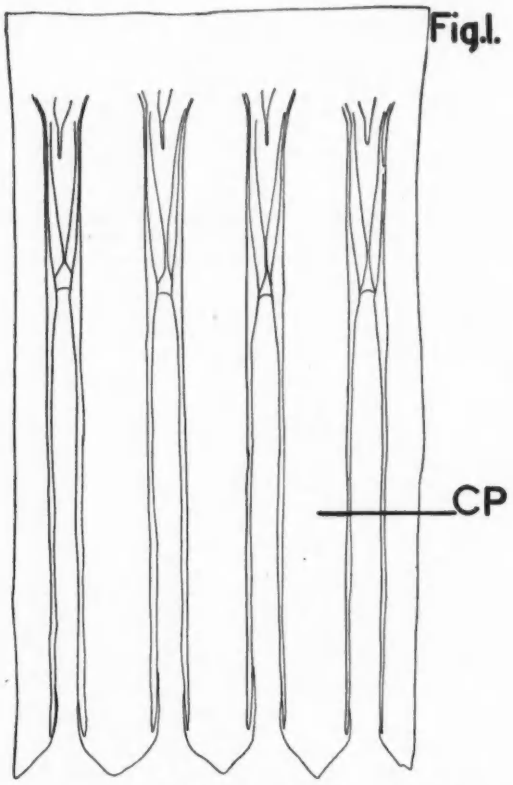

FIG. 1. Sclerotized intima of the proventriculus and oesophageal valve.

[1]Part of a thesis presented in accordance with the regulations for the degree of Master of Arts of the University of Western Ontario.

MATERIALS AND METHODS

Adults of *Macrobasis unicolor* Kirby were collected from plants of Blue Cohosh (*Caulophyllum thalictroides* (L.) Michx.) at Wrightville, Quebec, June 8, 1939.

Whole mounts were prepared to show the sclerotized lining of the proventriculus flattened out and divested of connective tissue and muscles. The digestive tract of a beetle was removed from the body and was fixed, by means of pins through the crop and mid-gut, to a layer of wax in a Syracuse watch glass. The digestive tract was covered with water. The wall of the proventriculus was cut longitudinally

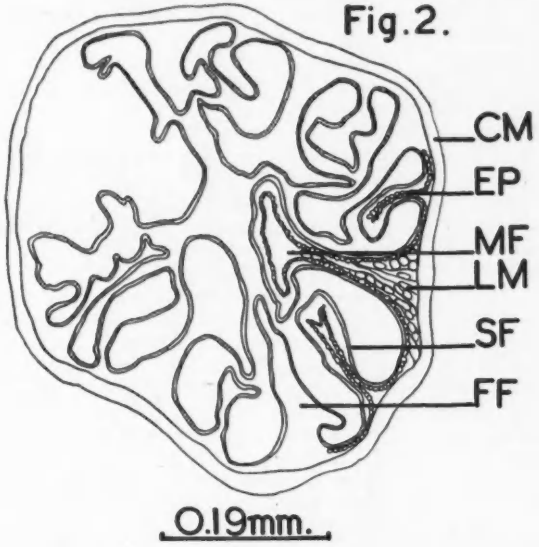

FIG. 2. Transverse section of the proventriculus.

INDEX FOR FIGURES 1, 2 AND 3

CM—circular muscle.
CP—projection of oesophageal valve.
EP—epidermal layer.
FF—finger-like fold.
I—intima.
LM—longitudinal muscle.
MF—mushroom-shaped fold.
MG—mid-gut.
OES—oesophagus.
Oes. V.—oesophageal valve.
SF—secondary fold.

with fine scissors and then the whole proventriculus was removed from the digestive tract and placed in a strong solution of potassium hydroxide. When the soft tissues had been dissolved the sclerotized intima was washed first with water, then with several changes of alcohols of increasing concentrations, then with absolute alcohol, and finally with xylol. It was then mounted in Canada balsam.

Serial transverse and longitudinal sections of the proventriculus were made. Material was fixed in Bouin's fixative, sectioned at 10μ, and stained with Haidenhain's haematoxylin and eosin.

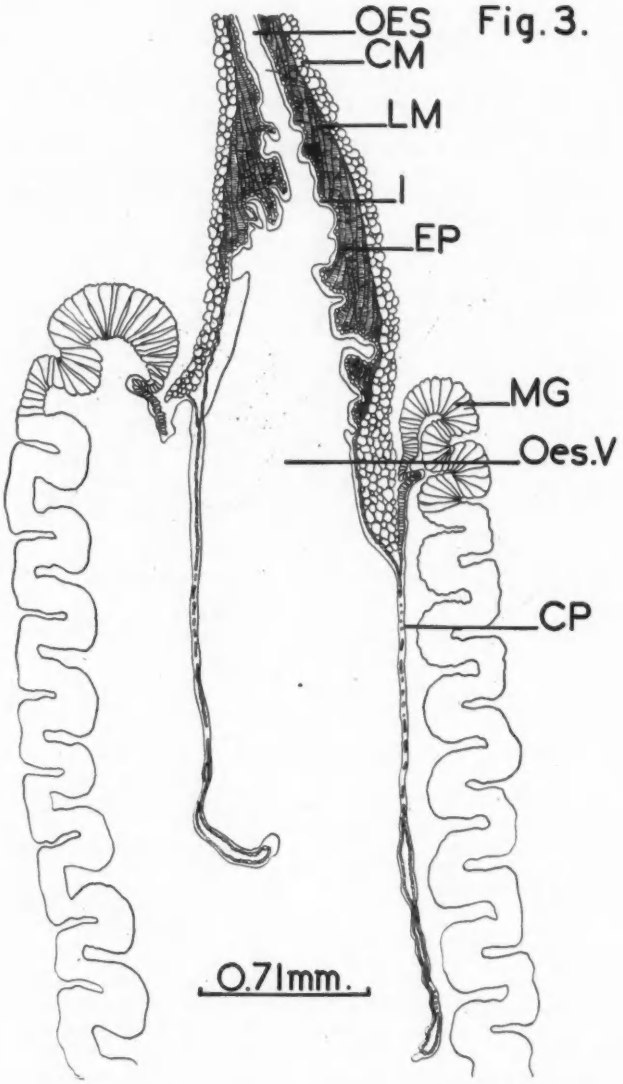

Fig. 3.

FIG. 3. Longitudinal section of the proventriculus and oesophageal valve.

DESCRIPTION

In *Macrobasis unicolor* the oesophagus is a tube about 0.5 mm. in diameter. At its posterior end it widens into the proventriculus which is about 0.75 mm. in diameter. Posteriorly the proventriculus gives way to the oesophageal valve (fig. 3–Oes. V.) which projects into the mid-gut (fig. 3–MG).

The inner lining of the proventriculus is the thin, sclerotized intima (fig. 3–I). It is continuous with that of the oesophageal valve which extends into the mid-gut in the form of four separate projections (fig. 1, 3–CP). These are flat and are about 0.5 mm. wide. Their outer borders are more heavily sclerotized than their central portions. Beneath the intima is a layer of minute epidermal cells (fig. 2, 3–EP); they form a double layer in the projections of the oesophageal valve. Next to the epidermal layer, in the oesophagus and proventriculus, is the longitudinal muscle (fig. 2, 3–LM). It is four to six strands in thickness. Surrounding the longitudinal muscle is circular muscle (fig. 2, 3–CM) which is the widest in the region of the oesophageal valve.

The folds of the sclerotized intima of the proventriculus are similar in form to those found by Everly in *Epicauta cinerea*. Four of the folds are roughly mushroom-shaped in transverse section (fig. 2–MF). Their ends almost meet in the centre of the lumen of the proventriculus. Between these fold are four somewhat finger-shaped folds (fig. 2–FF) which are shorter than the mushroom-shaped folds. Alternating with, and smaller than, the mushroom-shaped and finger-shaped folds are eight secondary folds (fig. 2–SF).

The foregoing description indicates that the proventriculus of *Macrobasis unicolor* Kirby is similar in form to that of *Epicauta cinerea marginata*. Both species have a tubular proventriculus and an oesophageal valve consisting of four long projections ("finger-like" processes—Everly) extending into the mid-gut. The proventriculus shows sixteen folds: four large mushroom-shaped folds with twelve smaller folds, in groups of three, between them.

The writer wishes to express his appreciation to Dr. J. D. Detwiler, University of Western Ontario, for his aid and interest in this work.

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OBSERVATIONS ON MEGARHINUS SPLENDENS WIEDEMANN WITH REFERENCE TO ITS VALUE IN BIOLOGICAL CONTROL OF OTHER MOSQUITOES[1]

(Diptera: Culicidae)

MAURICE RAY NEWKIRK[2]
Ashland College,
Ashland, Ohio

Megarhinus splendens is a beneficial mosquito because its larvae eat other mosquito larvae. The adults do not bite man. Whether these facts justify the use of *M. splendens* by man to control mosquitoes is questionable, and it is this question which the writer tried to answer in his study of *M. splendens* in New Guinea and the Philippine Islands during 1944 and 1945.

According to Howard, Dyar, and Knab (1912), *Megarhinus* may have been the first mosquito to evolve larvae with prehensile mouthparts which are used in seizing prey. These writers did not speculate on how the purely predacious behavior of *Megarhinus* larvae originated, but perhaps it arose from cannibalism, which is still such an important phase of its predacity. *Megarhinus* females, to continue with Howard, Dyar, and Knab, do not bite because they cannot: a rigid labium prevents them from piercing and sucking; instead, they feed on flower nectar.

Although what they said no doubt applies, Howard, Dyar, and Knab did not specifically mention *Megarhinus splendens* because of its Eastern origin and distribution. Of its presence in the Orient, Edwards (1924) said that it is "widely-spread"; and Knight, Bohart, and Bohart (1944), without reservations, called it "ubiquitous," which, if true, makes it unnecessary to be specific about *M. splendens*' distribution. And if Knight, Bohart, and Bohart's key is reliable, it is impossible anyway to define accurately the location of *M. splendens* because of the confusion that exists in the taxonomy of *M. splendens*, *M. inornatus* Walker, and *M. subulifer* Doleschall of the Australasian region.

FIELD OBSERVATIONS

Referring to its larval habitat, Edwards said that *Megarhinus splendens* "seems to be on the way to becoming a semi-domesticated species," meaning by this, that its breeding in artificial containers is increasing. Two years was, of course, too short a time for the writer to detect a trend; consequently, it can only be said that *M. splendens* larvae and pupae were collected from rain barrels in New Guinea, and from tree holes, bamboo stumps, leaf axils of the taro plant, tin cans,

[1]Contribution from the Department of Zoology and Entomology, The Ohio State University, Columbus, Ohio.

[2]Formerly a member of the 41st Malaria Survey Unit, Army of the United States.

coconut shells, and pasteboard boxes in the Philippines. In only one instance was it found in a ground pool, and that was an abandoned latrine pit at Milne Bay, New Guinea. Only two of these habitats, tree holes and leaf axils, may be considered natural, or original, and so it is not difficult to follow the argument that *M. splendens* originally bred in tree holes, or to understand Edwards' statement that it is now switching to artificial containers.

Evidently the mortality of immature *Megarhinus splendens* is high in nature. For, while eight pupae were removed from the latrine pit, two was the highest number of fourth instar larvae and pupae ever found in any of the other seven habitats. Assuming from the laboratory records (Table I) of oviposition that *M. splendens* lays an average batch of 11 fertile eggs in a habitat, the presence, in most instances, of only one or two survivors suggests that from 82 per cent to 91 per cent of the immature mosquitoes die. According to Paine (1934), the larvae do not succumb readily to starvation and, in the fourth instar, they can live as long as seven weeks without food. Paine mentioned Notonectidae and Gerridae as preying on *M. splendens*, but these predacious bugs appear to be limited to ground pools and barrels, two types of habitats which do not figure largely in the natural distribution of the mosquito. Since starvation and natural enemies probably exert a negligible influence on the mortality of *M. splendens*, it seems plausible to attribute the high death rate of its larvae to cannibalism, and to consider *M. splendens* itself as its greatest enemy.

Compared with its prey, in this instance, *Armigeres obturbans* Walker, *Aedes albopictus* Skuse, and *Tripteroides*, *Megarhinus splendens* appears to be sparsely distributed. At Palo, Leyte, out of 76 bamboo stumps that were inhabited by mosquitoes, only three contained *M. splendens*. Although this is an isolated case, it still may be significant because it was observed during November, 1944, when conditions were best for most mosquito reproduction: that is, monthly rainfall totaled 23½ inches, and a large blood reservoir was available for the females of *M. splendens*' prey. Its significance rests in the possibility that this is a typical case of minimum predacity, that *M. splendens* is least effective when other mosquitoes are most abundant; because, as Paine suggested, the minimum predacity of *M. splendens* may be expected during the period of greatest rainfall, owing to the increase in the number of habitats and to the corresponding decrease in the chance that *M. splendens* might share a habitat with another mosquito. Such a suggestion is acceptable, provided that *M. splendens* has a lower reproductive capacity than its prey. And that condition was true in the following laboratory study.

LABORATORY STUDIES

The laboratory investigation of *Megarhinus splendens* was conducted at Milne Bay, New Guinea, early in 1944. Two pupae, taken from a rain barrel, produced a female on May 25, and a male on May 31. Both adults died June 27, a day after they had been moved to a new site 20 miles away. Thus, the female lived 33 days, and the male, 27 days. While these adults were alive, the temperature, as measured by a maximum-minimum thermometer, ranged from 72° to 88° F.; and

the noon humidity, as ascertained by a sling psychrometer, varied between 77 per cent and 89 per cent.

This pair of mosquitoes was placed in a cage 24 inches high, 18 inches long, and 10½ inches wide. Subsequent pairs, obtained from the latrine pit, were put in cages 12x13x18 inches and 8x8½x7½ inches. Except for size, all cages were built alike. A wooden rectangular frame was nailed onto each end of a solid wood base; the framework was covered with mosquito netting which was extended at one end to form a sleeve, and the netting was held in place by wooden slats; finally, to provide additional support as well as a handle for carrying, the tops of the rectangular frames were connected by a piece of wood. Until a screened insectary could be built, the cages were kept in a pyramidal tent. In each cage the mosquitoes were furnished with a vial of 10 per cent sucrose in water, plugged with a cotton wick, as food, and a petri dish of water for oviposition.

Eggs were laid in the two largest cages. Copulation was not observed, but Paine, who saw one instance of it under natural conditions, described it as taking place during the day when the mosquitoes are at rest. The original female laid a total of 35 eggs in three batches during eight days (Table I). Except for the longer egg-laying period

TABLE I

OVIPOSITION RECORD OF THE *Megarhinus splendens* FEMALE

Date Laid	Eggs	Incubation Period	Temperature
June 12, 1944.....	8	2 days	73–85° F.
June 15, 1944.....	15	2 days	75–83° F.
June 19, 1944.....	12	2 days	73–83° F.

and the presence of three distinct egg batches, this agrees with Banks' (1908) report that a confined *Megarhinus splendens* lays from 40 to 50 eggs in two days. Paine was unable to rear *M. splendens* in the laboratory, but he noted three natural ovipositions of 5, 10, and 16 eggs. The first batch of eggs was laid in the laboratory 18 days after the female emerged and 12 days after she was paired with a male, which was a much longer preoviposition period than the week that Banks assigned to it. The eggs were found lying singly on the water in the petri dish; the egg-laying was not witnessed, but Paine, who watched it in nature, said that the female drops the eggs one by one as she hovers in the air about two inches above the water. Shaped like chicken eggs in miniature, the eggs were white, and measured 0.6 times 0.4 mm. A very slight discoloration, so slight that it was thought that the eggs were sterile, took place just before hatching, due probably to the larval hairs which could be seen through the egg membrane. After incubating two days, the eggs hatched, and then usually in the late afternoon or early evening. Only one of the 35 eggs was sterile.

To find out if *Megarhinus splendens* eggs could withstand drying, half of a batch of eggs from another female was removed from water for

24 hours. The eggs that were left on water hatched in two days while those that were dried never hatched. Paine reported similar results.

The larvae were white in the first instar; they reddened in the second instar, and this color deepened in the final two instars. In the laboratory *Megarhinus splendens* often ate each other; therefore, it was necessary to isolate them to get an accurate count of the prey that were eaten. Because it was found with *M. splendens* in the latrine pit, and also because it was very abundant, *Culex pullus* Theobald was used as food. The *Megarhinus splendens* larvae hatched from the eggs that were laid June 12 (Table I). Each *M. splendens* larva was kept in a pint jar of water with 10 *Culex pullus* larvae; the *C. pullus* larvae that

TABLE II

AVERAGE NUMBER OF *Culex pullus* LARVAE EATEN BY A *Megarhinus splendens* LARVA

M. splendens instar	*C. pullus* instar				Total
	1	2	3	4	
1	5	3	.....	.....	8
2	12	3	.....	.....	15
3	.....	.....	.....	10	10
4	.....	.....	.....	58	58
Total	17	6	.....	68	91

TABLE III

DURATION OF *Megarhinus splendens* LARVAL INSTARS

Instar	Number of Days	Temperature
1	2	72–83° F.
2	3	73–85° F.
3	4	73–83° F.
4	21	68–86° F.

were eaten, or that died, were replaced daily. The average number of *C. pullus* larvae eaten by each of three *Megarhinus splendens* larvae was 91 (Table II).

On a diet of *Culex pullus* larvae in fresh rainwater, *Megarhinus splendens* spent an average of 30 days in the larval period (Tagle III). The lengths of the larval instars agree with those reported by Paine for field-collected larvae, except for the fourth instar which, Paine said, lasts eight days. And with the temperature varying between 68° and 89° F., three *M. splendens* spent an average of seven days in the pupal stage. Thus, the duration of *M. splendens*' life cycle, from adult to adult in the laboratory, was 57 days. By substituting Banks' figure of seven days for the pre-oviposition period, and Paine's average of eight days for the fourth instar, the life history occupies 33 days.

The adults from the above three *Megarhinus splendens* pupae were about two-thirds the size of their parents. Their small size implies that the larval diet was inadequate. Each *M. splendens* ate about 40 less mosquito larvae than would have been the case, from Paine's figures, had it been collected in the field. But why, in the presence of abundant food, the laboratory-reared *M. splendens* did not eat more larvae, is a question that was not answered by the laboratory observations.

USE IN BIOLOGICAL CONTROL

Within the tropics *Megarhinus splendens* shares habitats with *Aedes aegypti* Linnaeus and *A. albopictus*, carriers of dengue, and *A. scutellaris* Walker and *Armigeres obturbans*, vectors of filariasis, to name some of the important ones; and unquestionably *Megarhinus splendens* exerts some influence on the control of these harmful mosquitoes.

In an attempt to reduce the filarial rate by eliminating its carrier, *Aedes scutellaris*, Paine introduced *Megarhinus splendens* into Fiji from Java. Paine arrived at Fiji, February, 1931, with 238 *M. splendens* in different stages of development. The immature *M. splendens* were put in shaded barrels of water, where a natural infestation of other mosquitoes furnished the *M. splendens* with more food than they could eat; and upon emerging, the *M. splendens* females returned to lay their eggs in the barrels. From this source Paine collected immature *M. splendens*, and by April, 1932, he had liberated almost 3000 of them in various parts of Fiji. Except where it encountered dense jungle and dry weather, *M. splendens* spread rapidly; yet Paine estimated its reduction of *Aedes scutellaris* at only 5 per cent, and considered this reduction a justification for the expense of the introduction.

Paine borrowed the barrel technique for rearing *Megarhinus splendens* from Pemberton (Williams, 1931), who, earlier in 1929, had attempted to introduce *M. inornatus* into the Hawaiian Islands from New Britain. Pemberton started with 290 larvae and pupae, August, 1929; the larvae were placed in barrels of water in a forested region back of Honolulu, and by December of the same year, *M. inornatus* had spread to neighboring tree holes; six months later, *M. inornatus* had completely disappeared. In a letter (1946) to the writer Pemberton said: "My interest has since revived in this matter and some day we will try *Megarhinus splendens* and make liberations in a better place in Hawaii."

CONCLUSION

From the life history presented in this paper, however, it is believed that *Megarhinus splendens* will probably occupy a minor role in the elimination of mosquitoes. Its long life cycle and few offspring, when compared with *Aedes albopictus* (in the laboratory life cycle occupied about four weeks; approximately 60 eggs were laid in each batch), and its low survival rate tend to nullify the importance of *Megarhinus splendens* in biological control. Even the predacity of its larvae is of doubtful value since, in the form of cannibalism, it appears to be responsible for the high mortality rate among the immature *M. splendens*. Finally, Paine's estimate of a 5 per cent reduction of *Aedes scutellaris* by

Megarhinus splendens compares unfavorably with the results obtained by airplane-sprayed DDT. For, when 5 per cent DDT in a diesel oil solution was used at the rate of 500 gallons per square mile, the day-biting mosquito population (including *Aedes scutellaris*) on Palawan Philippine Islands, was reduced about 92 per cent, from an average of 26 to an average of two mosquitoes biting per hour, weather remaining the same.

SUMMARY

After referring to some field observations of *Megarhinus splendens*, a laboratory study of the mosquito is given in detail. The use of the mosquito in biological control is reviewed and the conclusion is drawn that *M. splendens*' long life cycle, few offspring, and cannibalistic habit tend to render it ineffective as a means of controlling other mosquitoes.

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SIMULIDOS DE MEXICO, by L. VARGAS, A. MARTINEZ PALACIOS, and A. DIAZ NAJERA. Revista del Instituto de Salubridad y Enfermedades Tropicales. Vol. 7, No. 3, Septiembre, 1946. Biblioteca del Instituto de Salubridad y Enfermedades Tropicales, Mexico, D. F., Mexico. Price 75 cents.

This study of approximately 100 pages in size plus 25 pages of plates reports 77 species of Simulidae for Mexico. Eighteen of these species are described as new. In previous papers Vargas has described 8 new species. These 77 species are distributed in 3 genera. Two genera are represented by one species each and they are *Cnephia ochracea* and *Gigantodax wrighti*. The remaining 75 species are placed in 9 subgenera of the genus Simulium. Two of the subgenera are new.

Keys based on male genitalia are given for the determination of genera, subgenera, and species. Many larvae are described for the first time and there are keys for the separation of 37 species. There is a brief account of the geographica distribution of these insects in Mexico.

The 25 pages of plates with 162 figures illustrate larval and adult character istics for many species.

It should be pointed out that the regular publication in this journal of many papers on medical entomology by Dr. Vargas and others make it a necessary item in entomological libraries.—CARL E. VENARD.

NOTES ON THE BREEDING HABITATS OF AEDES (STEGOMYIA) AEGYPTI (LINNEAEUS)[1]

LEWIS BERNER,
Department of Biology,
University of Florida

Attempts at control and eradication of *Aedes aegypti* (L.) are almost invariably based on the assumption that the mosquito is absolutely domestic, or at least is confined to man-made breeding places. Habitats described for larvae include all types of domestic containers, i. e., tin cans, buckets, bowls, etc., automobile tires, concrete drains, artificial pools, and dozens of other water-holding articles which have been created by mankind. That a program involving the complete eradication of *Aedes aegypti* by eliminating water-holding articles is not all-inclusive, even with adequate inspection of domestic premises and human modifications of natural situations, has been repeatedly proven in West Africa.

The subgenus *Stegomyia* of the genus *Aedes* appears to be best developed and to have reached its greatest diversification in West Africa. Evidence also indicates that *Aedes aegypti* probably originated in this section of the continent and has recently become domesticated. Once the domestic habits were established, trade routes opened paths for the dissemination of the mosquito until it was no longer restricted to its place of origin, but was established throughout the world. Since the spread of the species, variations from the original West African stock have begun to appear in other parts of its enlarged range. Whether the varieties are as efficient vectors of yellow fever as *A. aegypti* is open to question. *Aedes simpsoni* (Theo.), another West African *Stegomyia* which has been shown to be a vector of yellow fever, seems to be following the same pattern as did *Aedes aegypti* in becoming a domestic mosquito. *A. simpsoni* is still found frequently in natural situations as well as in domestic receptacles, a condition which is shared with *Aedes aegypti* in West Africa; however, domesticity appears to be far more highly developed in *A. aegypti* than in *A. simpsoni*.

During the course of an intensive *Anopheles gambiae* eradication program on the Gold Coast (British West Africa), larvae of *Aedes aegypti* were brought into the laboratory hundreds of times for identification. Most frequently the specimens were from oil-drums used by the natives for storing drinking water, from cooking utensils which were placed outdoors unused, or from discarded tin cans and bottles. However, larvae, which on identification proved to be *Aedes aegypti*, were also found in natural water holes in the ground. When this was first discovered, we were of the belief that *A. aegypti* was never found breeding in natural pools, and we therefore suspected that the larvae might be a closely related species. This led to the rearing of the next batch

[1]These notes were prepared at the suggestion of Dr. D. B. Wilson of the International Health Division, Rockefeller Institute. The mosquitoes were identified by Kenneth G. Gogel.

from similar situations and the imagos were found to conform in all respects to the description of *Aedes aegypti*.

From this time on, a close check was kept of breeding places in which larvae were found. They include (besides artificial containers, concrete drains, etc.) several natural situations, of which the rarest was in water in the axils of a banana tree. Other natural environments include tree holes, small ground pools in protected places, and rock pools.

Descriptions of breeding places of the species state that it is rare or impossible to find *A. aegypti* breeding in man-made places with mud sides and bottom, unless the larvae were accidentally deposited there by being poured from some container. On the Gold Coast, larvae have frequently been observed in residual pools formed in earth drains where the grade of the ditch prevented complete removal of all water. G. H. E. Hopkins (1936, "Mosquitoes of the Ethiopian Region" Part I, p. 111, British Museum) considers that the original breeding places of *A. aegypti* were in tree holes. Brigadier G. M. Findlay, R. A. M. C. (personal communication) quotes E. Francis (1907, "Observations on the Life Cycle of *Stegomyia calopus*," Public Health Rep. USPH & Mar. Hosp. Serv. 22 : 381), "They [*A. aegypti*] were not found breeding in any [collection of water with] natural bottoms." Findlay further states, "The context shows that he meant puddles in the earth. Carter (1931, Yellow Fever: An Epidemological and Historical Study of Its Place of Origin, The Williams Wilkins Co.) is quite sure that this observation is correct. He quotes an unpublished report by Dr. Henry Hanson on the basis of his experience in Peru, 'We have found them breeding in no collection of water with exclusively earth (i. e. mud) sides at the surface of the water.' Carter corroborates this for Havana, United States, Panama, Guayaquil and Peru."

Findlay also states that in West Africa British workers have seen *A. aegypti* breeding on mud tops of African houses and in foorprints of children around the Lagoon at Saltpond, Gold Coast. Major P. F. Mattingly, R. A. M. C., has found *A. aegypti* breeding in grass-bottomed and grass-sided drains at Takoradi and Accra, Gold Coast.

From the observations of the writer, in West Africa, at least, it is necessary not only to examine water resulting from the carelessness of man, but also to keep a close check on natural situations as well, if *Aedes aegypti* and yellow fever are to be eradicated.

FICHIER ENTOMOLOGIQUE CHINOIS (Album of Chinese Insects).—This remarkable serial, published by the Musèe Heude, Shanghai, from 1939 to 1941, consists entirely of excellent color plates in separate folders, each accompanied by a reproduction of the original description of the insect. There are ten or more plates per series, and five series have appeared. Tht total of 59 plates treat 48 species: some with two views, or two sexes, illustrated. The first three series are colored by hand, and the last two are lithographed. The prices, U. S. $25.00 each for the first three series and U. S. $15.00 each for series 4 and 5, are high, but this fine type of entomological art is now almost extinct. Most of the species illustrated are from types of Chinese insects in the Musèe Heude, and many of them were described in the *Notes d'Entomologie Chinoise*.—J. L. GRESSITT.

STUDIES OF PISTOL CASE-BEARER PARASITES[1]

JOHN H. BEACHER,[2]
University of Delaware,
Newark, Delaware

The pistol case-bearer, *Coleophora malivorella* Riley (LEPIDOPTERA, COLEOPHORIDAE), is a native American insect which was described by Riley (1878). Gould (1931) recorded its range as extending from Virginia to Kansas and northward to Canada. Thorough reports on its life history have been given by Gould (1931 and 1936) and by Steiner and Worthley (1941).

In most areas, the pistol case-bearer has been considered as a curiosity rather than as a pest. Serious outbreaks on the foliage and fruit of apple have occurred infrequently, however, in several sections of eastern and central United States and in Canada.

Although biological control has been regarded as a dominant factor in reducing the pistol case-bearer to a status of minor importance as an apple pest, the literature contains only passing reference to the parasites of this insect. Riley (1878) first indicated the importance of parasitism in controlling *C. malivorella* by stating that the amount of parasitism by a minute Chalcid fly "increased to such an extent that it bids fair to render additional remedies against the coleophora unnecessary." Lintner (1882) noted that pistol case-bearer injury in an Erie County, Pennsylvania, apple orchard was no longer serious due to the beneficial results of an attack which had been made on the host by a Chalcid parasite during 1880–1881. Lowe (1897) found three unidentified parasite species attacking this host in New York. During the decade 1929–1939, Gould and Geissler (1940) compiled a comprehensive list of parasites reared from *C. malivorella* in Virginia and West Virginia.

In conjunction with investigations conducted by Steiner and Worthley (1941) on the life history and control of the pistol case-bearer at Arendtsville, Pennsylvania, these studies were undertaken during 1940 and 1941 to determine the importance of the natural enemies of this insect.

EGG PARASITES

Leaves containing 1,500 host eggs were collected at random from various orchards within the infested region near Arendtsville, Pennsylvania, on July 16, 1940, several days after the peak of egg deposition had occurred. A small paper punch was used to separate the egg from the surrounding leaf tissue, after which the eggs were placed in glass vials, and observed daily for emerging parasites. Care was taken to remove

[1]Published as Miscellaneous Paper No. 31, with the approval of the Director of the Delaware Agricultural Experiment Station. Publication 212 and Scientific Article 135 of the Department of Entomology, May 2, 1947.

Studies in Pennsylvania were conducted under the direction of H. M. Steiner and, in Delaware, at the request of L. A. Stearns. Acknowledgment is made to E. Gould for the parasite specimens used in identification work.

[2]Assistant Research Fellow, Entomology.

as much of the leaf tissue around the egg as possible, in order to eliminate parasites, other than those of the egg itself, which might have been present within the leaf tissue.

No parasites were reared from these eggs. Gould and Geissler (1940), however, list *Anagrus epos* Gir., *Trichogramma minuta* Riley, and *Zagrammosoma* sp. as recovered from pistol case-bearer eggs in Virginia and West Virginia.

PARASITES OF FIRST- AND SECOND-INSTAR LARVAE

A collection of 1,000 first-instar host larvae was made from several orchards near Arendtsville, Pennsylvania, on July 30, 1940. No parasites were reared from this material. Furthermore, the literature does not mention previous recovery of parasites at this stage of larval growth in the pistol case-bearer, although Doner (1936) records a species of *Derosternus* as an ectoparasite in the mines of young cherry case-bearer larvae, *Coleophora pruniella* Cl.

A similar collection of 1,000 host larvae on August 25, 1940, did not yield any parasites.

PARASITES OF THIRD-INSTAR LARVAE

Pistol case-bearer hibernating (third-instar) larvae were found to be highly susceptible to attack by several parasites. Collections[3] of

TABLE I

PARASITISM OF HIBERNATING (THIRD-INSTAR) PISTOL CASE-BEARER LARVAE

	Pennsylvania	Delaware*	Virginia	Illinois
Host Larvae (Number)	577	869	3,345	526
Parasitism (Per Cent)	4.5	22.2	9.7	1.9
Host Survival (Per Cent)	83.4	64.1	84.0	72.1
Parasite Survival (Per Cent)	55.3	85.5	91.4	0.9

*Delaware larvae collected in April, 1941; other samples, in April, 1940.

overwintered larvae made at Arendtsville, Pennsylvania, Winchester, Virginia, and Kinmundy, Illinois, during the first week of April, 1940, showed a parasitism of 4.5, 9.7, and 1.9 per cent, respectively (Table I).

Collections of overwintered larvae made at Camden, Delaware, during April, 1941, showed a parasitism of 22.2 per cent. The low parasitism of the Illinois larvae may have been due to the fact that they were collected from one tree, instead of a representative collection from several orchards as in other localities. A wide variation may be noted between the survival of over-wintered hosts and parasites.

Parasitization of the overwintering host larvae occurred generally throughout September and October, the majority of them being fixed

[3]Acknowledgment is made to H. M. Steiner, W. S. Hough, and S. C. Chandler for these collections.

in hibernating positions on the twigs. Some, however, were parasitized while still feeding upon the foliage at this time, and never assumed hibernating positions. A paralysis induced by the parasite stings caused larval activity to cease, and the host remained attached to the leaf, thereby dropping to the ground at leaf-fall. Observations on the establishment of the host larvae for hibernation showed a loss of 11.6 per cent upon completion of leaf-fall. It is not known whether this loss is entirely attributable to parasite attack.

The parasites recovered from the several collections listed in Table I are as follows: ***Eurydinota lividicorpus*** Gir. (94.1 per cent), ***Habrocytus phycidis*** Ashm. (4.2 per cent), and ***Eupelmus cyaniceps*** var. ***amicus*** Gir. (1.7 per cent). The parasites overwintered within the host cocoons as pupae and, with the rise of temperature in the latter part of April, began to emerge from the cases. The peak of emergence occurred during the first and second weeks of May.

PARASITES OF FOURTH- AND FIFTH-INSTAR LARVAE

Collections of host cases were made from eight apple orchards distributed throughout an area of pistol case-bearer infestation involving

TABLE II

EMERGENCE OF PISTOL CASE-BEARER PARASITES, ARENDTSVILLE, PENNSYLVANIA, JUNE-JULY, 1940

Orchard	Cases Examined	Parasitized Hosts	Parasite Emergence	Per Cent	
				Parasitism	Host Emergence
Baltzley	407	39	54	9.6	58.2
Barber	317	33	63	10.4	80.4
Blue Ribbon	1265	78	113	6.2	57.3
Boyer	300	22	45	7.3	71.0
Keller	300	72	120	24.0	60.3
Kunkle	282	26	50	9.2	36.5
Roth	304	19	21	6.2	83.9
Taylor	300	35	98	11.7	61.0
Totals and Averages	3475	324	564	9.3	62.2

18 square miles near Arendtsville, Pennsylvania, during June 15–20, 1940. Parasite emergence from this material commenced on June 18, and continued until July 29. There were two peaks of emergence, one occurring on June 25, and another on July 15–17. Parasitism varied from 6 to 24 per cent among the eight orchards. An average parasitism of 9.3 per cent was recorded from the 3475 cases under observation (Table II).

Fifteen species of parasites were recovered from this material as follows:[4] ***Acrolyta aletiae*** Ashm., ***Anachaetopsis tortricis*** (Coq.), ***Aphe-***

[4]Identified by C. F. W. Muesebeck, A. B. Gahan, D. G. Hall, and R. A. Cushman, U. S. Bureau of Entomology and Plant Quarantine.

linus mali (Hald.), *Dibrachys cavus* (Walk.), *Eupelmus cyaniceps* var. *amicus* Gir., *Eurytoma tylodermatis* Ashm., *Eurydinota lividicorpus* Gir., *Epiurus indagator* (Cress.), *Habrocytus phycidis* Ashm., *Hemiteles tenellus* (Say), *Microbracon gelechiae* (Ashm.), *Microbracon pygmaeus* (Prov.), *Spilochalcis albifrons* (Walsh), *Sympiesis* sp., and *Tetrastichus* sp.

All parasites attacked the mature pistol case-bearer larva, with the exception of *Anachaetopsis tortricis* (Coq.), which was reared from the host pupa. *Dibrachys cavus* (Walk.) and *Hemiteles tenellus* (Say) were recovered as secondary parasites of *Eurydinota lividicorpus* Gir. and *Habrocytus phycidis* Ashm. One female *Aphelinus mali* (Hald.) was reared from the host as an accidental parasite.

Collections of host cases were made in two apple orchards at Camden, Delaware, during June, 1941. The pistol case-bearer infestation

TABLE III

EMERGENCE OF PISTOL CASE-BEARER PARASITES, CAMDEN, DELAWARE, JUNE-JULY, 1941

Orchard	Cases Examined	Parasitized Hosts	Parasite Emergence	Per Cent	
				Parasitism	Host Emergence
Lord Bros.....	200	19	41	9.5	80.0
Thomas.....	630	203	305	32.2	61.6
Totals and Averages...	830	222	346	26.8	66.0

was restricted to a small area in this vicinity. The population in both orchards was very light, although extensive defoliation had occurred several years previously.

Parasite emergence from this material commenced on June 3 and continued until July 11. Peak emergence occurred between June 14 and 20. Average parasitism for the two orchards amounted to 26.8 per cent (Table III). Five species of parasites were reared from the 830 host cocoons under observation, namely, *Epiurus indagator* (Cress.), *Eupelmus cyaniceps* var. *amicus* Gir., *Eurydinota lividicorpus* Gir., *Habrocytus phycidis* Ashm., and *Hemiteles tenellus* (Say).

EFFECT OF TEMPERATURE UPON EMERGENCE OF HOST AND PARASITES

Eight daily observations were made in order to determine the optimum temperature for emergence of the host and its parasites at Arendtsville, Pennsylvania, during June and July, 1940. The host cocoons were kept in an open screened insectary to approximate field conditions.

According to the results summarized in Table IV, 74.8 per cent of the adult case-bearers and 57.0 per cent of the parasites emerged during a temperature range of 71–80° F. As the optimum temperature usually

existed between 9:00 A. M. and 3:00 P. M., maximum emergence of both host and parasites occurred during this period of time.

TABLE IV

INFLUENCE OF TEMPERATURE UPON EMERGENCE OF THE PISTOL CASE-BEARER AND ITS PARASITES, ARENDTSVILLE, PENNSYLVANIA, 1940

Date	Temperature Range							
	51–60° F.		61–70° F.		71–80° F.		81–90° F.	
	Host	Parasites	Host	Parasites	Host	Parasites	Host	Parasites
June 27	.....	.....	.....	.....	4	12	15	8
28	.....	.....	.....	.....	22	13	.....	.....
29	.....	.....	34	7	32	29	.....	.....
30	15	.....	4	6	40	1	.....	.....
July 1	.....	.....	11	5	52	3	.....	.....
2	.....	.....	.....	.....	121	6	.....	.....
3	.....	4	23	17	.....	.....	.....	.....
4	8	.....	3	3	211	8	.....	.....
5	.....	1	19	9	212	7	.....	.....
6	.....	.....	9	.....	231	6	.....	.....
7	2	1	2	3	165	8	43	.....
8	.....	.....	5	.....	113	9	104	12
9	.....	.....	2	2	99	7	116	.....
10	.....	.....	.....	1	126	6	30	2
11	.....	.....	.....	.....	54	7	55	11
Totals	25	6	112	53	1482	122	363	33
Average Per Cents	1.3	2.8	5.7	24.8	74.8	57.0	18.2	15.4

LONGEVITY OF PARASITES

Immediately upon emerging from the cocoons, the parasites were placed in shell glass vials loosely stoppered with cotton. Food was supplied in the form of a raisin mounted on a pin which was inserted in the stopper. All insects were kept in shaded situations to prevent undue activity. Daily observations were recorded on the longevity of the principal case-bearer parasites (Table V).

The female *Eurydinota lividicorpus* Gir., the most important primary parasite, having a maximum length of life at 65 days, showed a mean longevity of 25.5 days when supplied with food, against a life span of but 6.6 days without food. *Microbracon pygmaeus* (Prov.) showed a mean longevity of 22.1 days with food, as against only 7.4 days without food. Other species of parasites were not tested in detail, due to the limited numbers available.

RELATIVE ABUNDANCE OF PARASITES

The parasites reared from mature pistol case-bearer larvae and pupae at Arendtsville, Pennsylvania, ranked in the following order of importance (Table VI): *Eurydinota lividicorpus* Gir. (59.9 per cent), *Habrocytus phycidis* Ashm. (8.9 per cent), *Microbracon pygmaeus* (Prov.)

TABLE V

LONGEVITY OF PISTOL CASE-BEARER PARASITES

Species		Number of Individuals		Maximum Length of Life in Days		Minimum Length of Life in Days		Mean Length of Life in Days	
		Male	Female	Male	Female	Male	Female	Male	Female
Microbracon pygmaeus (Prov.)	(A)	25	18	5	9	3	3	4.4	7.4
	(B)	13	29	18	58	3	4	12.0	22.1
Eurydinota lividicorpus Gir.	(A)	56	137	9	9	2	3	5.2	6.6
	(B)	74	190	24	65	3	4	11.3	25.5
Epiurus indagator (Cress.)	(A)	10	10	5	6	2	3	3.3	4.5
	(B)	19	12	9	12	4	4	5.4	8.1
Habrocytus phycidis Ashm.	(A)	10	10	6	7	4	3	4.2	5.7
	(B)	10	20	20	34	7	11	12.9	19.3
Anachaetopsis tortricis (Coq.)	(A)	1	5	3	7	.....	3	3.0	4.4
	(B)	1	21	4	7	.....	2	4.0	4.0
Eupelmus cyaniceps var. *amicus* Gir.	(A)	12	23	8	17	2	3	5.1	10.4
	(B)	10	25	13	31	4	5	8.4	16.5
Spilochalcis albifrons (Walsh)	(A)	0	1	.....	3	.....	.....	.....	3.0
	(B)	1	5	6	10	.....	6	6.0	8.0

(A)—without food; (B)—with food.

TABLE VI

RELATIVE ABUNDANCE OF PISTOL CASE-BEARER PARASITES*

SPECIES	PENNSYLVANIA Per Cent			DELAWARE Per Cent		
	Total	Males	Females	Total	Males	Females
Eurydinota lividicorpus Gir.	59.9	26.3	73.7	80.3	25.5	74.5
Habrocytus phycidis Ashm.	8.9	40.0	60.0	12.0	31.0	69.0
Epiurus indagator (Cress.)	5.3	73.3	26.7	4.6	12.5	87.5
Microbracon pygmaeus (Prov.)	7.4	38.1	61.9	.....	.....	.....
Hemiteles tenellus (Say)	3.9	27.3	72.7	2.6	22.2	77.8
Eupelmus cyaniceps var. *amicus* Gir.	4.2	25.0	75.0	0.5	50.0	50.0
Anachaetopsis tortricis (Coq.)	4.4	12.0	88.0	.....	.....	.....
Misc. spp.	6.0	33.3	66.7	.....	.....	.....
Totals and Averages	100.0	30.7	69.3	100.0	25.6	74.4

* Based on 3475 host cases in Pennsylvania and 830 host cases in Delaware.

(7.4 per cent), *Epiurus indagator* (Cress.) (5.3 per cent), *Anachaetopsis tortricis* (Coq.) (4.4 per cent), *Eupelmus cyaniceps* var. *amicus* Gir. (4.2 per cent), and *Hemiteles tenellus* (Say) (3.9 per cent).

The emergence of *Eurydinota lividicorpus* Gir. occurred uniformly throughout the period in which the case-bearers were under observation. In contrast, *Microbracon pygmaeus* (Prov.) emerged in abundant numbers during the period June 18–30; *Habrocytus phycidis* Ashm., from July 1 to 12; and *Eupelmus cyaniceps* var. *amicus* Gir. in the latter portion of the emergence period, namely, July 13–29.

At Camden, Delaware, the emergence of parasites approximated that of the same species in Pennsylvania. *Eurydinota lividicorpus* Gir. comprised 80.3 per cent of the total number of parasites reared, followed by *Habrocytus phycidis* Ashm. (12.0 per cent), *Epiurus indagator* (Cress.) (4.6 per cent), *Hemiteles tenellus* (Say) (2.6 per cent) and *Eupelmus cyaniceps* var. *amicus* Gir. (0.5 per cent).

Sex ratios of the parasites reared from the above-named localities are given in Table VI.

CUMULATIVE EFFECT OF PARASITISM

Since the pistol case-bearer has but one generation per year and all stages are exposed to parasite attack due to their more or less stationary positions and protective cases, it is apparent that the cumulative effect of parasitism must be considered in order to obtain an accurate indication of the importance of parasites in reducing the host population.

The parasitism of mature case-bearer larvae and pupae (9.3 per cent, Table II), and of overwintering larvae (4.5 per cent, Table I) observed in the Arendtsville collections, induces the assumption that a total cumulative parasitism of 13.8 per cent existed for the pistol case-bearer during 1940, not including the possible parasitization of host eggs and of the earlier larval-instars from which no recoveries were made and, also, the parasitized host larvae which fell from their feeding positions on the trees. Likewise, a total cumulative parasitism of 49.0 per cent (Tables I and III) existed for overwintering and mature pistol case-bearer larvae in Delaware during 1941.

The value of predators in reducing populations was not determined. However, Steiner and Worthley (1941) observed two mirids, *Diaphnidia pellucida* Uhler and *Hyaliodes vitripennis* Say, feeding on pistol case-bearer larvae at several periods during the year.

Hemiteles tenellus (Say) was found to be a secondary parasite of *Eurydinota lividicorpus* Gir. and *Habrocytus phycidis* Ashm. *Dibrachys cavus* (Walk.) was reared from *E. lividicorpus* Gir. Both hyperparasites also attacked the mature case-bearer larvae. Although few hyperparasites were recovered from the collections of host cocoons, it is probable that these species and others may play an important role in reducing primary parasite populations, thus permitting serious pistol case-bearer outbreaks on apple.

ALTERNATE HOSTS OF PARASITES

Since adults of the principal pistol case-bearer parasite, *Eurydinota lividicorpus* Gir., upon emergence from the host cocoons in June and

July, were not detected as being parasitic upon the young host larvae until September, it seems probable that an alternate host or hosts are present to enable the parasite to tide over the period until the newly-developing case-bearer larvae become large enough to permit the parasite to obtain sufficient sustenance.

The unspotted tentiform leaf-miner, *Parornix prunivorella* Cham., which occurred in large numbers on the foliage in every orchard from which case-bearer collections were made, was investigated as a possible alternate host of the parasites. One thousand larval "tents" were enclosed in glass vials, and were observed daily for emerging parasites. Two pistol case-bearer parasites, *Sympiesis* sp. and *Tetrastichus* sp., were recovered in sufficient numbers to establish a parasitism of 16.2 per cent. Efforts to rear *E. lividicorpus* Gir. on this host proved fruitless, although females were observed attempting to deposit eggs within the larval "tents."

Empty cylindrical cases of an unknown species of case-bearer (possibly cigar case-bearer) were found attached to the trunks of peach and sour-cherry trees in the vicinity of a pistol case-bearer infested orchard. It is assumed that this species had made its way to the trunks of these trees from the surrounding vegetation on which it had matured, since no cases were observed on the twigs and foliage. However, examination of the surrounding vegetation during August and September, 1940, did not reveal the presence of this insect. Parasite emergence holes were found in the cases of this species, and their similarity to those formed by *E. lividicorpus* Gir., et al., leads to the assumption that parasitism is probably effected by the same parasite species that attack the pistol case-bearer. Parallel life cycles of these two species of *Coleophora*, on the other hand, reduces the possibility that the unknown case-bearer serves as an alternate host. Further research is necessary to clarify this aspect of biological control. It is possible that the lack of alternate or secondary hosts is a limiting factor in the size of the parasite population, with a resultant increase in host numbers.

EFFECT OF SPRAYING UPON PARASITE ABUNDANCE

Prior investigations do not provide information concerning the effect of artificial control measures upon the parasite populations of *Coleophora* species. Since periodic collections of host larvae were not made throughout an entire season in a specific locality, data cannot be presented which would give a complete analysis of spraying effects within a given orchard.

All orchards, from which host collections were made at Arendtsville, Pennsylvania, received the recommended schedule of lead arsenate sprays for codling moth control. Therefore, comparisons between sprayed and unsprayed plots are impossible. Collections of overwintered pistol case-bearer larvae were made from unsprayed and sprayed orchards at Camden, Delaware, on April 10, 1941. Examination of these samples showed a parasitism of 14.8 per cent for the sprayed orchards, as opposed to 26.5 per cent for the unsprayed orchard. Similar collections of mature host larvae on June 3 showed a parasitism of 9.5 per cent for the sprayed orchard, while that of the unsprayed orchard reached 32.2 per cent.

SURVEY OF PISTOL CASE-BEARER PARASITES

A review of pistol case-bearer parasites, as recorded by various workers, is given in Table VII. The classification used is similar to that employed in Cornell University Agricultural Experiment Station Memoir 101, "A List of the Insects of New York," 1926.

TABLE VII

PARASITES OF THE PISTOL CASE-BEARER

SPECIES	LOCALITY					RECORDED BY§
	West Virginia	Virginia	Pennsylvania	Delaware	Illinois	
HYMENOPTERA						
CHALCIDOIDEA						
APHELINIDAE						
Aphelinus mali (Hald.)	...	...	x	...	...	Beacher
CALLIMOMIDAE						
Monodontomerus ? n. sp.	x	...	...	...	...	Gould
CHALCIDIDAE						
Hockeria sp. (probably new)	x	...	...	...	...	Gould
Microdontomerus anthonomi Cwfd.	...	x	...	...	...	Gould
Spilochalcis albifrons (Walsh)	x	...	x	...	...	Gould, Steiner
Spilochalcis torvina (Cress.)	x	...	...	...	...	Gould
ELASMIDAE						
Elasmus setosiscutellatus Cwfd.	x	...	...	...	...	Gould
ENTEDONTIDAE						
Horismenus microgaster (Ashm.)	x	...	...	...	...	Gould
EULOPHIDAE						
Cirrospilus flavicinctus Riley	x	...	...	...	...	Gould
Eulophus magnisulcatus Gir.	x	...	...	...	...	Gould
**Sympiesis* n. sp.	x	...	x	...	...	Gould, Steiner
Sympiesis argenticoxa Gir.	x	...	...	...	...	Gould
Tetrastichus sp.	x	...	x	...	...	Gould, Steiner
†*Zagrammosoma* sp.	...	x	...	...	...	Gould
EUPELMIDAE						
**Eupelmus allyni* (French)	x	...	...	...	...	Gould
**Eupelmus cyaniceps* var. *amicus* Gir.	x	x	x	x	x	Gould, Steiner, Beacher
EURYTOMIDAE						
Eurytoma tylodermatis Ashm.	...	...	x	...	...	Steiner
Eurytoma sp. (very close to *Phoebus* Gir.)	x	...	...	...	...	Gould
MYMARIDAE						
†*Anagrus epos* Gir.	...	x	...	...	...	Gould
PTEROMALIDAE						
Catolaccus aeneoviridis Gir.	x	...	...	...	...	Gould
Coleopisthia (*Trineptis*) *hemerocampae* Gir.	x	...	...	...	...	Gould
‡*Dibrachys cavus* (Walk.)	...	...	x	...	...	Steiner
**Eurydinota lividicorpus* Gir.	x	x	x	x	x	Gould, Steiner, Beacher
Habrocytus sp. Nov. (possibly *phycidis*)	x	...	...	...	...	Gould
Habrocytus thyridopterigis Howard	x	...	...	...	...	Gould
**Habrocytus piercei* Cwfd.	x	...	...	...	...	Gould

TABLE VII—(*Continued*)

Species	Locality					Recorded by§
	West Virginia	Virginia	Pennsylvania	Delaware	Illinois	
**Habrocytus phycidis* Ashm.	x	...	x	x	...	Gould, Steiner, Beacher
Hypopteromalus inimicus Mues.	x	...	...	...	...	Gould
**Hypopteromalus tabaccum* Fitch.	x	...	...	...	...	Gould
TRICHOGRAMMIDAE						
‡*Trichogramma minuta* Riley	x	...	...	...	...	Gould
ICHNEUMONOIDEA						
BRACONIDAE						
Bassus coleophorae Rohw.	x	...	...	...	...	Gould
Bassus n. sp.	x	...	...	...	...	Gould
Doryctinae: n. g. and n. sp. (may be a new species of *Rhoptrocentrus*)	x	...	...	...	...	Gould
Macrocentrus instabilis Mues.	x	...	...	...	...	Gould
Macrocentrus n. sp.	x	...	...	...	...	Gould
Meteorus vulgaris Cress.	x	...	...	...	...	Gould
**Microbracon gelechiae* (Ashm.)	x	...	x	...	...	Gould, Steiner
**Microbracon pygmaeus* (Prov.)	x	...	x	...	...	Gould, Steiner
Opius sp.	x	...	...	...	...	Gould
Rhoptrocentrus sp.	x	...	...	...	...	Gould
ICHNEUMONIDAE						
Acrolyta aletiae Ashm.	...	...	x	...	...	Steiner
Angitia sp.	x	...	...	...	...	Gould
Hemiteles gracilariae Ashm.	x	...	...	...	...	Gould
‡*Hemiteles tenellus* (Say)	x	...	x	x	...	Gould, Beacher
**Epiurus indagator* (Cress.)	x	...	x	x	...	Gould, Steiner, Beacher
Epiurus sp. (probably *indagatir* (Cress.))	x	...	...	...	...	Gould
Hyposoter annulipes (Cress.)	x	...	...	...	...	Gould
Itoplectis conquisitor Say	...	x	...	...	...	Gould
VESPOIDEA						
BETHYLIDAE						
Goniozus hortorum Brues.	x	...	...	...	...	Gould
DIPTERA						
TACHINIDAE						
Anachaetopsis tortricis (Coq.)	x	...	x	...	...	Gould, Steiner
SCATOPSIDAE						
Rhegmoclema atrata (Say)	x	...	...	...	...	Gould
Swammerdamella brevicornis Meig.	...	x	...	...	...	Gould

* More abundant species.

† Egg parasites.

‡ Secondary parasites.

§ Gould records for 1940; Steiner records for 1941.

BIOLOGY OF EURYDINOTA LIVIDICORPUS GIR.

Observations were recorded on the life history of *E. lividicorpus* Gir. the most important primary parasite of the pistol case-bearer.

DESCRIPTION OF SPECIES

Girault (1917) described this species as follows:

"Female: Length 1.65 mm. Dark metallic blue, the wings hyaline, the base and apex of the tibiae and tarsi white. Clypeus striate, gently concave at apex. Head and thorax punctate. Propodeum with distinct, curved lateral carina and no other, the carina forming the lateral rim of the large neck; no spiracular sulcus, the spiracle elliptical, cephalad. Petiole a little longer than wide. Parapsidal furrows half complete from cephalad. Abdomen depressed, delicately scaly distad, segment 2 occupying a fourth of the surface, its caudal margin convex, entire. Antennae inserted somewhat above the ends of the eyes, the scape slender, reaching to the top of the vertex; pedicel twice longer than wide at apex, much longer than any funicle joint; ring-joints unequal; funicle 1 (a ring joint?) quadrate, narrower than the following joints; 2 and 3 subquadrate, wider than 1; 6 twice wider than long. Stigmal vein long and slender, slightly shorter than the marginal which is slightly shorter than the post-marginal.

"The male is similar but funicle 1 is wider than long, still more like a ring-joint, the pedicel shorter; also the cephalic tibiae are reddish-yellow."

COPULATION AND OVIPOSITION

Adult parasites were kept in glass vials (2¼ inches in length), and a raisin, mounted on a pin inserted in the stopper of the vial, served as a supply of food and moisture. The adults were observed also to feed at the puncture holes of the host following oviposition. Longevity of the males and females has been discussed previously (Table V).

Copulation took place shortly after emergence. The males pursued the females as soon as they appeared but, upon mounting, were often dislodged by them before successful copulation could be effected. Copulation usually extended for 25 minutes, and several cases were noted in which it lasted 45 minutes or more.

In general, a female required about one week to develop an interest in the host. Case-bearer larvae, introduced into the glass vials, were untouched by newly-emerged parasites, which were more intent upon copulation and feeding. Finally, the oviposition response manifested itself, and the introduction of the host larvae caused an immediate action on the part of the female. Walking carefully over the entire surface of the case, she touched every portion with her antennae, which vibrated rapidly and were held in a widely divergent forward position.

After these preliminary movements, the abdomen was curved downward, and the tip applied to the point of the case where the ovipositor was to be inserted. The point of insertion was usually in the center of the case, the head of the female being directed toward the distal end of the case. In this manner, the thoracic region of the larva was pierced, causing the paralyzing agent to quickly reach a vital part.

Noticeable effort was exerted in piercing the case and, frequently, the female selected several points before the ovipositor could be inserted. During each thrust of the ovipositor, the wings were held flatly over the abdomen. A variable number of stings were required before the host was killed. Small case-bearer larvae ceased movement after but a few thrusts, while mature larvae required as many as 15 or more thrusts before the paralyzing agent became effective. Between thrusts, the females either remained perfectly quiet on the case or, more often, repeated their searching movements over the surface of the case as described previously. Additional thrusts were not necessarily made through the original puncture of the first thrust; other points were frequently chosen.

After being stung, the case-bearer larvae would first retire into the case, but would soon crawl about in an excited manner, in an attempt to dislodge the parasite. Mature larvae frequently succeeded in dislodging the parasite by jerky motions, but the female would immediately return to the case, and inject the ovipositor for several additional thrusts. On occasions when the larvae attempted to crawl about, the female would pinch the thoracic region with its mandibles, causing them to retire into the cases.

When the host larvae finally remained quiet for a few minutes, the true egg thrust occurred, and the ovipositor remained inserted in the case for over a minute. *E. lividicorpus* is an ectoparasite, and the eggs are deposited upon the surface of the larvae. Under laboratory conditions, from one to eight eggs were deposited on an individual, if only a limited number of hosts were present. In the field, 17 larvae were observed on a single host.

The duration of the oviposition period was usually 10 days, with maximum deposition occurring within six days after the beginning of egg laying. The maximum number of eggs deposited by one female was 35, over a period of 10 days (seven eggs on one day), and the average number of eggs deposited per female was 21. One female was observed ovipositing on the 27th day, and another was observed attempting to paralyze a case-bearer on the 44th day, but oviposition did not occur.

DEVELOPMENT OF LARVA AND PUPA

In life history studies with *E. lividicorpus* Gir., it was necessary to remove the parasitized larvae from their cases, using insect pins mounted in match sticks as instruments for opening the cases. A camel-hair brush was utilized in transferring the naked larvae to glass slides. Individual parasite larvae attached to the host were placed in the deep cells of "hanging-drop" slides and were sealed with a cover slip, held in place by a drop of water, similar to the method used by Doner (1936).

These were kept in a desiccator, in which a relative humidity of 77 per cent was maintained by a saturated solution of potassium bromide. This procedure enabled the parasite larvae to develop rapidly, and prevented desiccation of the host larvae. It was found to be highly important to keep the desiccator in darkness when not being observed, since light caused the parasite larvae to leave the host and to wander around the glass slide.

Extreme care was necessary in removing the host larvae from the case, immediately after parasitization, since the parasite eggs are easily injured by brushing against the wall of the case. In every instance, where a parasite larva was dislodged from the host after it had commenced feeding, attempts to rear the larva proved futile, even though the parasite was placed directly on the host at the same spot on which it had been feeding previous to removal.

Larval maturity was attained in approximately 11 days after eclosion and, by that time, the larval host was reduced to a flattened, dried mass, with the parasite larvae completely filling the case. Frequently, the entire host was devoured, with the exception of the chitinized portions of the body. In one instance, 10 parasite larvae reached full growth on a single host and later emerged as adults.

When mature (2 mm. in length and 0.5 mm. in width), the parasite larva rested for a short period and then constructed a fine, white cocoon within the case, completing it within 18 to 24 hours. An increase in the size of the thoracic region and a constriction appearing between the thorax and abdomen was indicative of the pre-pupal stage. The pupal stage usually lasted seven days, although this period varied from seven to ten days.

The rate of development of larvae in a single case-bearer cocoon was found to vary, some pupating two to four days in advance of the others.

The complete life cycle averaged 20 days, as follows: egg stage, 36 to 48 hours; larval stage (three instars), 11 days; and pupal stage, 7 days. The minimum life cycle observed was 18 days and the maximum, 22 days; the length varied according to the duration of the pupal period. There appears to be at least two generations annually.

EMERGENCE FROM HOST CASES

After from seven to 10 days as pupae, the adult parasites issue from the pistol case-bearer cocoon by chewing a small, round exit hole through the wall. Invariably, the parasites used one exit hole, as many as 10 emerging from a single host case. This hole is usually located on the side of the posterior third of the case. None of the parasites attempted to emerge via the ventral slit in the curved end of the case, through which the adult host would normally have made its emergence.

The sex ratio of parasites emerging from single cases varied greatly; males outnumbering females and vice versa. Several specific examples are cited as follows: case one (two males, six females), case two (four males, five females), case three (four males, no females), case four (five males, two females).

SUPERPARASITISM AND MULTIPARASITISM

A female *E. lividicorpus* supplied with a limited number of hosts was found to deposit as many as 10 eggs on a single host larva. Doner (1936) reported a total of 14 eggs being deposited on an individual host. In several instances, as many as 10 parasites emerged from one host case, the host larva having attained maturity and being large enough to furnish the amount of sustenance necessary to rear the parasites.

E. lividicorpus and *Habrocytus phycidis* were noted emerging from a single pistol case-bearer cocoon in June, 1941. Doner (1936) records

specimens of *E. lividicorpus* and *Eupelmella vesicularis* emerging from a single case of *Coleophora pruniella* Cl. The same author also observed *E. lividicorpus* feeding upon a larva of *Microbracon pygmaeus* as a secondary parasite. *Hemiteles tenellus* (Say), as previously reported, was a secondary parasite upon *E. lividicorpus*.

OCCURRENCE IN OTHER SPECIES OF COLEOPHORA

Hosts of *E. lividicorpus* Gir., recorded to date, include only members of the genus *Coleophora*. A survey of the literature has revealed the notations of *E. lividicorpus* as a parasite of *Coleophora pruniella* Cl. by Petch and Armstrong (1926) and Doner (1936), and of *Coleophora sacramenta* Hein by Essig (1926).

SUMMARY

Fifteen species of parasites were reared from the mature larvae and pupae of the pistol case-bearer, *Coleophora malivorella* Riley, at Arendtsville, Pennsylvania, during June and July, 1940, as follows: *Acrolyta aletiae* Ashm., *Anachaetopsis tortricis* (Coq.), *Aphelinus mali* (Hald.), *Dibrachys cavus* (Walk.), *Eupelmus cyaniceps* var. *amicus* Gir., *Eurytoma tylodermatis* Ashm., *Eurydinota lividicorpus* Gir., *Epiurus indagator* (Cress.), *Habrocytus phycidis* Ashm., *Hemiteles tenellus* (Say), *Microbracon gelechiae* (Ashm.), *Microbracon pygmaeus* (Prov.), *Spilochalcis albifrons* (Walsh), *Sympiesis* sp. and *Tetrastichus* sp.

Parasitism varied from 6 to 24 per cent for all cases examined in eight apple orchards at Arendtsville.

Five species of parasites, namely, *Epiurus indagator* (Cress.), *Eupelmus cyaniceps* var. *amicus* Gir., *Eurydinota lividicorpus* Gir., *Habrocytus phycidis* Ashm., and *Hemiteles tenellus* (Say), were reared from the same host collected in two apple orchards at Camden, Delaware, during June and July, 1941. Parasitism varied from 9 to 32 per cent of the cases examined.

Eurydinota lividicorpus Gir. was the most important primary parasite of the mature host larvae, comprising 59.9 per cent of the total number of parasites reared at Arendtsville, and 80.3 per cent of those at Camden.

No parasitism was recorded for the egg or the first, two, larval instars of this host. Collections of overwintering host larvae in Pennsylvania, Delaware, Virginia, and Illinois showed parasitism of 4.5, 22.2, 9.7, and 1.9 per cent, respectively. *E. lividicorpus* Gir. was the most important parasite in all instances and comprised 94.1 per cent of the total recoveries.

The cumulative effect of parasitism in host collections at Arendtsville, during 1940, averaged 13.8 per cent for one generation of the host, excluding possible parasititization of the host egg and earlier larval instars from which no recoveries were made and, also, the amount of parasitized larvae which fell from their feeding positions on the trees. Cumulative parasitism for the overwintering and mature hosts averaged 49.0 per cent at Camden.

The unspotted tentiform leaf-miner, *Parornix prunivorella* Cham., served as an alternate host for the two pistol case-bearer parasites, *Sympiesis* sp. and *Tetrastichus* sp.

Spraying was found to materially affect parasite population. Parasitism amounted to 32.2 per cent in an unsprayed Delaware orchard, as compared with 9.5 per cent in an orchard sprayed in accordance with the recommended program for control of important apple pests.

Hemiteles tenellus (Say) was observed as a secondary parasite of *Eurydinota lividicorpus* Gir. and *Habrocytus phycidis* Ashm. *Dibrachys cavus* (Walk.) was reared from *Eurydinota lividicorpus* Gir. Both hyperparasites also attacked the mature pistol case-bearer larvae.

A list of pistol case-bearer parasites, as recorded by various workers, is included.

Observations were made on the biology of *Eurydinota lividicorpus* Gir., the principal primary parasite of the pistol case-bearer. The average number of eggs deposited per female was 21. A maximum life span of 65 days was recorded for the female, with a mean longevity of 25.5 days. The number of eggs deposited on a host varied from one to 17. The complete life cycle averaged 20 days as follows: egg stage, two days; larval stage (three instars), 11 days; and the pupal stage, seven days. The minimum life cycle was 18 days, and the maximum was 22 days. The length varied according to the duration of the pupal stage. There appears to be at least two generations annually.

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GENERAL CATALOGUE OF THE HEMIPTERA, FASCICLE IV, FULGOROIDEA, PART 8, DICTYOPHARIDAE, by Z. P. METCALF. 246 pages, 1946. Published by Smith College, Northampton, Mass. Price $3.00.

Previous issues of the Catalogue have been noticed in the Annals from time to time. This part continues the excellent format of earlier numbers, as well as the comprehensive data: extensive bibliography, citations of genotype, and notes on geographic distribution. As a lepidopterist the reviewer envies the hemipterists their opportunity to secure such a useful catalogue at a cost within the means even of a college professor. —A. W. L.

CHINESE LONGICORN BEETLES OF THE GENUS LINDA
(Coleoptera: Cerambycidae)[1]

J. LINSLEY GRESSITT
Lingnan Natural History Survey and Museum,
Lingnan University, Canton, China

Linda is closely related to the large genus *Oberea*, and differs from it principally in having the prothorax quite short, strongly though bluntly tuberculate laterally, more or less swollen or nodse on the disc, and transversely grooved or constricted near apex and base, and in having the elytra considerably broader than the basal portion of the prothorax. *Linda* is largely Chinese in its constituency, and only a few species occur outside the country, in neighboring areas including Indo-China, Assam and perhaps Burma and the East Indies.

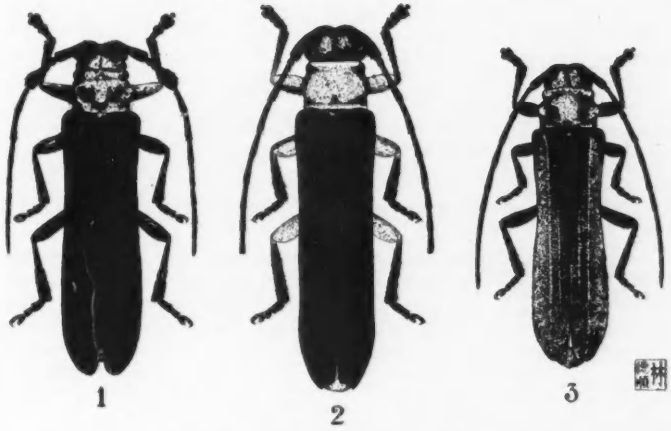

FIG. 1. *Linda fasciculata* Pic; female; W. Hills, near Kunming, Yunnan. (× 2.5)
FIG. 2. *Linda major* Gressitt; holotype, female. × (2.5)
FIG. 3. *Linda nigroscutata* (Fairmaire); female; Kunming, Yunnan. × (2.5)

Linda was erected in 1864 by Thomson for one of two Chinese species which had been earlier described in *Amphionycha* by Chevrolat. In 1902 Fairmaire erected the genus *Miocris* for a single new species, *nigroscutatus*, from Yunnan. This genus was placed by Fairmaire in the tribe Pyrestini of the subfamily Cerambycinae, and compared with *Erythrus* and *Plutonesthes*. In 1907 Pic made a reference to *Miocris*

[1]Contribution from the Lingnan Natural History Survey & Museum, Lingnan University.

nigroscutatus, but placed it after *Linda* in a part dealing with a number of Phytoeciini. In the Coleopterorum Catalogus (Aurivillius, 1912 and 1923) and in the Catalogus Insectorum Sinensium (Wu, 1937), *Miocris nigroscutatus* occurs both in the Pyrestini and the Phytoeciini, with identical references in each instance. This peculiar circumstance can be explained by stating that, though *Miocris* was placed by its author in the Pyrestini, it actually has no such relationship, but merely resembles members of that tribe in form, coloration and certain superficial structural characterists, and actually belongs in the tribe Phytoeciini of the subfamily Lamiinae. What is more, however, I can find no valid characters to justify the retention of *Miocris* as a distinct genus. In 1939 Beeson and Bhatia used the combination *Linda nigroscutata* in a biological paper on the basis of a specimen identification made by a specialist, but without any reference to previous generic placement or indication of new combination.

I am inclined to suspect that the genus *Dasylinda* Thomson may also prove to be a synonym of *Linda*, since most of the characters ascribed to it for separation from the latter may be found in one or two of Pic's Chinese species of *Linda* which I do not believe should be generically separated from the latter.

Genus **Linda** Thomson

Linda Th., 1864, Syst. Cer. 122, 400 (type: *Amphionycha femorata* Chevrolat); Lacordaire, 1872, Gen. Col. 9: 851, 870; Savio, 1929, Notes d'Ent. Chinoise 1: 3; Matsushita, 1933, Fac. Agr. Hokkaido Imp Univ. 34: 416, 424; Gressitt, 1939, Lingnan Sci. 18: 98, 107; 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 8: 40.

Miocris Fairmaire, 1902, Bull. Soc. ent. France, 245 (type: *M. nigroscutatus* Fairm.), new synonym.

Long, slender, somewhat cylindrical; elytra more or less flattened basally, generally broadened preapically, in dead specimens often appearing dehiscent because of warping from dessication; antennae nearly always shorter than body, cylindrical, not very slender, usually black, sometimes ringed with pale; prothorax transverse, bluntly tuberculate laterally, swollen on disc; elytra more often completely black, in some species predominantly pale; head, prothorax and ventral surfaces of body pale, sometimes marked with black.

In most species the pale parts appear yellowish testaceous to reddish ochraceous in dried specimens, whereas in life they are actually bright pinkish red. The extensive pale coloration of *nigroscutata*, however, appears to be of a slightly different nature, being a permanent orange-red, and only slightly paler than in species of *Erythrus* of the tribe Pyrestini (Cerambycinae).

Nine species of *Linda* were listed from China by Liu in 1934 and Wu in 1937. This paper discusses 15 species, and the total number for the genus now reaches 17. Little is known of the biology of species of *Linda*. In 1929 Savio gave some notes on the habits and larva of *fraterna*, and in 1942 the writer added a small amount of information. Some work has been done on *nigroscutata* in Yunnan (unpublished?) and Assam.

KEY TO THE CHINESE SPECIES OF LINDA

1. Third antennal segment with a tuft of dark hairs 2
   Third antennal segment lacking a distinct tuft of dark hairs 4
2. Elytra not almost entirely black 3
   Elytra almost entirely black, only very narrowly bordered with pale at extreme apices ..... **fasciculata**
3. Elytra testaceous apically and narrowly margined with testaceous laterally, **apicalis**
   Elytra testaceous, with a black area on basal portion of disc of each, **gibbosicollis**
4. Antennae entirely black, non-annulated 5
   Antennae annulated, at least in part, with pale 9
5. Elytra largely red or testaceous 6
   Elytra entirely black 7
6. Elytra largely red with a black spot or stripe behind scutellum; pronotum with four small black spots ..... **nigroscutata**
   Elytra orange except for pitchy black humeri; pronotum entirely pale; legs and ventral surfaces largely pitchy ..... **tricostata**
7. Elytra subregularly punctured; body more or less stout; antennae relatively thick and shorter than body 8
   Elytra irregularly punctured; body slender; antennae relatively slender and as long as body ..... **gracilicornis**
8. Head and prothorax densely punctured; elytra with round punctures; femora entirely testaceous; length over 20 millimeters ..... **major**
   Head and prothorax sparsely punctured; elytra with square punctures; femora black; length less than 20 millimeters ..... **atricornis**
9. Antennae irregularly ringed with pale; ground color broadly testaceous on bases of fourth to sixth segments, and sometimes with pale hairs on bases of seventh and eighth segments 10
   Antennae regularly ringed with pale hairs on bases of third or fourth and following segments 12
10. Sides of hind thorax partly black, the remainder red 11
    Sides of hind thorax entirely testaceous (or red?) ..... **pratti**
11. Sixth and following antennal segments entirely black; scutellum rounded-truncate apically; elytra broadly and subobliquely truncate apically, **signaticornis**
    Sixth to eighth antennal segments with pale hairs at bases; scutellum broadly emarginate apically; elytra emarginate apically ..... **fraterna**
12. Antennae ringed with pale hairs on bases of fourth and following segments; elytra with more than six rows of punctures 13
    Antennae ringed with pale hairs on bases of third and following segments; vertex largely black; sides of prothorax feebly swollen; elytra with only about six rows of punctures ..... **macilenta**
13. Ventral surfaces of body entirely testaceous; elytra entirely black 14
    Ventral surfaces of body largely black; elytra pale apically and along suture ..... **nigriventris**
14. Elytra with about 12 punctures across middle of each; prothorax moderately swollen laterally; pronotal disc subevenly convex (S. E. China), **femorata**
    Elytra with about 16 punctures across middle of each; prothorax strongly protuberant laterally; pronotal disc with three prominent partly isolated tubercles (Formosa) ..... **annulicornis**

1. **Linda annulicornis** Matsushita

Linda annulicornis Mats., 1933, Jl. Fac. Agric. Hokkaido Imp. Univ. 34: 424, fig.[1]

Head, prothorax and ventral surfaces of body pinkish (testaceous in dried specimens); elytra entirely black; antennae ringed with pale on bases of fourth and following segments; elytra with about 12 punctures across middle of each.

Some specimens (California Academy of Sciences) were taken in Formosa in 1932 and 1934 by the writer.

Distribution: Formosa[1].

2. **Linda apicalis** Pic

Linda apicalis Pic, 1906, Mat. Long. 6(1): 17[1]; Gressitt, 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 8: 40.

Moderately robust and slightly elongate; dull; partly black, partly testaceous; antennae slightly exceeding middle of body, black, third and following segments ringed with gray basally, the third very thick and bearing a weak brush of hairs apically; head testaceous, extensively marked with black on each side of vertex and frons; prothorax short and broad, swollen, testaceous; scutellum testaceous; elytra slightly constricted towards middle, black, a large apical spot, and a narrow lateral margin, testaceous; legs black with anterior femora, the basal portions of middle femora, and the coxae entirely, testaceous. Length 22 mm. (After Pic).

A specimen from Tibet is in the American Museum of Natural History in New York. New to Tibet.

Distribution: Yunnan[1]; Tibet.

3. **Linda atricornis** Pic

Linda atricornis Pic, 1924, Mel. Exot. Ent. 41: 19[1]; Savio, 1929, Notes d'Ent. Chinoise 1: 3[2]; Gressitt, 1939, Notes d'Ent. Chinoise 6: 126[3]; 1940, ibid. 7: 197[4]; 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 7: 10[5]; 1942, ibid. 8: 41.

Head (except eyes, labrum and mandibles), prothorax, scutellum, ventral surface of body, basal thirds of femora, extreme bases of tibiae, and tarsal claws, reddish testaceous; antennae, elytra, eyes, labrum, mandibles and most of legs black; pale portions clothed with fine silvery pubescence and erect hairs; bases of elytra and undersurfaces of antennae with sparse erect black hairs. Head densely and coarsely rugulose-punctate; vertex shallowly grooved; inferior eye-lobes slightly broader than deep; antennae five-sixths as long as body, scape nearly as long as third segment, following gradually shorter; prothorax one-half again as broad as long, swollen above and behind middle of each side, its surface densely punctured except on each side of middle of disc; scutellum declivitous, truncate, elytra two and one-half times as long as head and prothorax united, slightly narrowed in middle, each impressed with about ten subregular rows of deep, squarish punctures, most of them larger than distances separating them, apices obliquely emarginate-truncate. Length 14–18.5 mm.; breadth 3.5–4.2.

A specimen (American Mus. Nat. Hist.) was collected at Yenping, Fukien Prov., June 12, 1917, probably by the Rev. Harry Caldwell.

Distribution: Kiangsu (Shagnhai [1 2], Kao-ghiao[2], Lou-bou[3]); Chekiang (Tien-mu Shan[3]); Fukien (Yen-ping[4]); Chahar (Yangkiaping[4]); N.E. Szechuan; Sikang: "Upper Kuanhsien."[5]

4. **Linda fasciculata** Pic

Linda fasciculata Pic, 1902, Mat. Long. 4 (1): 32[1], Fig. 1; Gressitt, 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 7:10[2]; 1942, ibid. 8: 40.

Moderately long; prothorax and scutellum reddish ochraceous; ventral surfaces of body almost entirely reddish or yellow; head, antennae, elytra and legs largely black. Head black between and behind eyes, remainder yellow; antennae not reaching elytral apices, black, with bases of third to seventh segments ringed with whitish cinereous, the third having a brush of dark hairs apically; prothorax

short, very broad, distinctly tuberculate at sides; elytra a little broader than prothorax, very long, slightly constricted at middle, subangulately rounded at apices, which are narrowly reddish, deeply and rather closely punctured and with traces of feeble costae; legs black except for yellow femora and bases of tibiae of anterior pair and bases of femora and tibiae of middle pair; ventral surfaces of body yellow with sides of breast largely black. Length 17–21 mm.; breadth 3.8–5.

Three specimens (Lingnan Nat. Hist. Mus.) were taken in the Western Hills, alt. 2100 meters, near Kunming, Yunnan Prov., July 7, 1940, by the writer.

Distribution: "Szechuan" ("Mongtze"[1]); Yunnan (Western Hills[2]· near Kunming).

5. **Linda femorata** (Chevrolat)

Amphionycha femorata Chevr., 1852, Rev. Zool. (2) 4: 418[1].
Linda femorata, Thomson, 1864, Syst. Ceramb.: 122; Lacordaire, 1872, Gen. Col. 9: 870; Schwarzer, 1925, Ent. Blatter 21: 154[2]; Savio, 1929, Notes d'Ent. Chinoise 1: 4[3]; Gressitt, 1937, Lingnan Sci. Jl. 16: 620[4]; 1939, ibid. 18: 108[5]; 1939, Notes d'Ent. Chinoise 6: 127[6]; 1940, ibid. 7: 197[7]; 1942, Spec. Publ. Lingnan N. H. Surv. ; Mus. 7: 10[8]; 1942, ibid 8: 41.

Ventral surfaces, prothorax, scutellum, head and femora largely testaceous; elytra and antennae black, latter clothed with silvery gray pubescence on bases of fourth to last segments; head with a black band across vertex; legs black except for basal two-thirds of middle and hind femora and basal fourth-fifths of anterior pair. Antennae four-fifths as long as body; scape fully as long as third segment; prothorax nearly twice as broad as long, swollen at sides and on disc; elytra deeply and subseriately punctured on basal two-thirds. Length 17–20 mm.; breadth 4.2–5.

Two specimens are in the Lingnan Nat. Hist. Mus. from southwestern China: Shui-tang, alt. 6800–8000 feet, pine mountains 20 miles east of Yunnan-fu (Kunming), Yunnan, Aug. 28, 1934, E. R. Tinkham, and Kweiyang, alt. 1060 meters, Kweichow, July 12, 1940, J. L. Gressitt.

Distribution: Kiangsu (Shanghai [1,3]); Chekiang (T'ien-mu Shan[6]); Kiangsi (Hong Shan[4]); Fukien; Kwangtung (Tai-yong[5]); Kwangsi (Ling-yuen[7]); Kweichow (Kweiyang[8]); Yunnan (Shui-tang[8]); Formosa (Kosempo[2]).

6. **Linda fraterna** (Chevrolat)

Anphionycha fraterna Chevr., 1852, Rev. Zool. (2) 4: 419[1].
Oberea seminigra Fairmaire, 1887, Ann. Soc. Ent. Belg. 31: 134[2].
Linda fraterna, Gahan, 1894, Trans. Ent. Soc. London: 486; Savio, 1929, Notes d'Ent. Chinoise 1: 5–8, figs. 1–7[3]; Liu, 1934, Lingnan Sci. Jl. 13: 658[4]; Gressitt, 1937, ibid. 16: 620[5]; 1939, ibid. 18: 108[6]; 1939, Notes d'Ent. Chinoise 6: 127[7]; 1940, Lingnan Sci. Jl. 19: 19[8]; 1942, ibid, 20: 214[9]; 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 1: 54, fig. 40[10]; ibid. 8: 41.
Linda seminigra, Fairmaire, 1895, Ann. Soc. Ent. Belg. 39: 188.
Linda seminigra var. *subtestacea* Pic, 1906, Mat. Long. 6 (1): 17[11].
Linda seminigra var. *luteonotata* Pic, 1907, Mat. Long. 6 (2): 24[12].

Reddish testaceous; elytra entirely black; occiput partly black; antennae and legs largely black; antennae testaceous on basal half of fourth, and extreme bases of fifth to eighth segments; metaepisternal-

metasternal suture black; legs testaceous on basal portions of femora. Prothorax one-half again as broad as long, strongly swollen above, finely punctured; elytra with deep, subregular punctures and with three feebly raised longitudinal lines. Length 9.5–17 mm.; breadth 1.9–4.5.

One specimen (Lingnan Nat. Hist. Mus.) was taken at Lung-ping-hui, Lien Distr., N. Kwangtung, May 18–20, 1934, by F. K. To. The Musée Heude has specimens from Chusan and Mo-kan Shan in Chekiang, and from Fukien.

Host plants: ***Prunus japonica*** Thunb.[3], ***Cydonia japonica*** Pers.[3] (Shanghai); ***Rubus*** sp.[9,10] (Kwangtung).

Distribution: Kiangsu (Shanghai[1,3], Wou-si[3], Tcheng-kiang[3], Nanking[4]; Chekiang[2] (T'ien-mu Shan[7], Chusan, Mo-kan Shan); Kiangsi (Hong Shan[5]); Fukien; Kwangtung (White Cloud Mt.[6], near Canton, Taam-yuen-tung[6], Lung-ping-hui, Yao Shan[6], Loh-kung[8], Waichow[9]); Yunnan[11,12]; Formosa.

7. **Linda gibbosicollis** Pic

Linda gibbosicollis Pic, 1915, Mel. Exot. Ent. 13: 12[1]; Gressitt, 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 8: 41.

Elongate; opaque; black; head partly, and thorax, scutellum and femora more or less, testaceous; elytra testatceous, marked on disc with black, largely testaceous posteriorly; antennae black, third and following segments ringed with gray basally; prothorax short, strongly tuberculate on disc. Length 19 mm. (After Pic).

Distribution: Tibet[1].

8. **Linda gracilicornis** Pic

Linda gracilicornis Pic, 1907, Mat. Long. 6 (2): 24[1]; Gressitt, 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 7: 10[2]; 1942, ibid. 8: 41.

Moderately narrow and elongate; testaceous, with mouth-parts, eyes, antennae, elytra, tibiae (except at bases) and tarsi, black; head testaceous, quite deeply grooved along middle; antennae long and slender, nearly reaching elytral apices, entirely black; prothorax testaceous, short, moderately broadened, swollen at sides, narrowed and weakly constricted anteriorly and posteriorly, raised, but not gibbous, on center of disc; scutellum testaceous; elytra black, broader than prothorax, slightly constricted towards middle, obliquely emarginate apically with external angles prominent, discs lacking distinct costae, strongly and irregularly punctured; ventral surfaces of body testaceous, chest marked with black; femora and bases of tibiae testaceous, remainder of legs black. Length 20 mm. (After Pic).

Two specimens (University of Nanking Coll. of Agric. and Lingnan Natural History Museum) were taken at Chengtu, Szechuan in June, 1938, and in upper Kwan-hsien, near the Szechuan-Sikang border, by the University of Nanking. These do not agree completely with Pic's description, and are referred tentatively to this species. They have the ventral surfaces of the body entirely pale, and the femora largely black. The Chengtu specimen measures 17.5 mm. in length and 3.5 in breadth.

Distribution: Yunnan[1]; Szechuan[2].

9. **Linda macilenta** Gressitt, new species

Male.—Head, prothorax and ventral surfaces largely pale and elytra black; head reddish, pitchy black on vertex and upper part of frons, except median line, and front of antennal support, as well as side of neck behind upper portion of eye; labrum, mandibles, margins of genae, and distal palpal segments pitchy; antennae black with basal fifth or so of third and following segments ringed with pale hairs; prothorax and scutellum testaceous; ventral surfaces of body reddish testaceous; legs black with coxae and basal two-thirds to four-fifths of femora testaceous; tarsal claws reddish. Head, thorax and abdomen clothed with thin silvery buff pubescence and some flying hairs; elytra with short dull reddish hairs; antennae without any tufts of hairs.

Head as broad as prothorax, convex anteriorly, medially grooved, deeply and somewhat closely punctured. Antennae nearly as long as body, rather slender; scape about as long as third segment; third to tenth gradually decreasing in length, subcylindrical; eleventh about as long as sixth. Prothorax nearly as long as broad, subrectangular, very feebly swollen laterally, moderately and subevenly convex on disc; surface rather sparsely and not very deeply punctured. Scutellum relatively small, slightly broader than long, subtrapeziform. Elytra narrow, obliquely subemarginate-truncate apically; disc of each with six subregular rows of deep squarish punctures at middle, the fifth row from suture uneven and almost a double row, punctures somewhat confused at base and towards apex, much finer near the latter. Ventral surfaces irregularly punctured. Posterior femora not quite reaching to apex of second abdominal segment. Length 14 mm.; breadth 2.55.

Holotype, male (No. 58,338 U. S. Nat. Mus.) Mt. Omei, 10,000 ft., Szechuan Province, W. China, July, 1936, D. C. Graham.

Differs from *L. femorata* (Chevr.) in being more narrow with the prothorax less swollen laterally and the antennae ringed with pale hairs from third instead of fourth segment, the ventral surface without any black marking.

10. **Linda major** Gressitt

(Fig. 2)

Linda major Gress., 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 3: 8[1]; 1942, ibid. 8: 41.

Female.—Large; subcylindrical; relatively broad; pronotal disc subevenly swollen. Body orange testaceous to reddish ochraceous in dried specimen (probably pinkish red in life); labrum, eyes, antennae, elytra, tarsi and distal two-thirds of tibiae black: head reddish ochraceous, slightly paler above and darker on clypeus and palpi; mandibles reddish on outer faces, pitchy black below and distally; antennae entirely black, finely clothed with silvery pubescence basally and with closer and thinner dull golden brown pubescence distally, with a few fine subperpendicular hairs below: pale on scape and blackish beyond; prothorax orange testaceous with a slight ochraceous tinge; scutellum ochraceous; elytra black except at extreme edge bordering scutellum, which is ochraceous; ventral surfaces of body orange testaceous with a slight ochraceous tinge; femora and bases of tibiae reddish ochraceous,

remainder of legs black with heavy dull golden brown hairs; tarsal claws pitchy red. Body surfaces largely clothed with pale golden buff pubescence; elytra thinly clothed with reddish black pubescence and with a few fine suberect black hairs basally.

Head not quite as broad as prothorax, coarsely and densely rugose-punctate, depressed and grooved between antennal insertions and slightly raised between superior eye-lobes. Antennae about four-fifths as long as body, moderately stout, slightly compressed; scape not quite as long as third segment; third a little longer than fourth; following segments gradually decreasing in length. Prothorax slightly more than one-third again as broad as long, heavily and somewhat closely punctured; sides broadly and bluntly swollen; disc evenly convex except for an upward prolongation of each lateral swelling near posterior margin. Scutellum broader than long, declivitous, slightly emarginate-truncate apically, minutely punctured. Elytra broadest at base, feebly narrowed in central portion and very slightly broadened preapically; apices narrowed and obliquely subemarginate-truncate; surface of each deeply impressed with subrounded punctures arranged in about ten irregular longitudinal rows, the punctures becoming smaller and more irregular posteriorly, but extending as far as apices. Ventral surfaces of body heavily punctured at sides of metathorax and first abdominal segment, much more finely punctured towards apex of abdomen. Length 22.4 mm.; breadth 4.8.

The holotype, a female, is in the collection of the College of Agriculture, University of Nanking. This species was rather briefly diagnosed in the original description.

Differs from *Linda atricornis* Pic in being larger and of much stouter build, in having the head and pronotum more densely punctured, the elytra with less regular puncturation and with round instead of square punctures, and in having the sutural borders of the elytra, and the femora entirely, ochraceous. This is probably the largest species of the genus.

Distribution: Anhwei (Hwang Shan[1]).

11. **Linda nigriventris** Heller

Linda nigriventris Heller, 1923, Ent. Blätter 19: 74[1]; Gressitt, 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 8: 41.

Black; prothorax, scutellum, apical fifth and lateral margins of elytra, femora, mesosternum, half of middle femora, base of posterior coxae, and last abdominal segment entirely, testaceous. Body extremely narrow; head black, dark brown behind vertex, clothed with rows of black, suberect hairs, coarsely seriate-punctate, a row of large punctures fringing superior eye-lobes; third to eighth antennal segments briefly white basally; prothorax coarsely punctured except for a series of swellings forming an arched transverse row, outer posterior tubercle clothed with fine white hairs; scutellum yellow, impunctate; elytra coarsely punctured between three impunctate costae, outermost costa joining external margin, punctures disappearing before apices, black, brownish along suture, becoming testaceous posteriorly, joining testaceous marginal stripes before apices, leaving black portion of each rounded behind; ventral surfaces black, pro- and mesosterna, entire

anterior, and bases of middle and posterior, femora, and last abdominal segment, testaceous. Length 19 mm.; breadth 4.5. (After Heller).

Distribution: Szechuan (Kwan-hsien[1]); Sikang (Ta-tsien-lu[1]).

12. **Linda nigroscutata** (Fairmaire)

(Fig. 3)

Miocris nigroscutatus Fairmaire, 1902, Bull. Soc. Ent. France: 245[1].
Linda nigroscutata, Beeson & Bhatia, 1939, Ind. For. Rec., Ent. (n. s.) 5: 130[2]; Gressitt, 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 8: 40.

Body bright orange-red; antennae, eyes, labrum and legs black; pronotum with four small round black spots in form of a trapeze on disc; elytra with an elongate scutum-shaped black mark behind scutellum, reaching to end of basal quarter or basal third of suture, and the humeri generally also marked with a black spot; metathorax and abdomen largely black, but with posterior border of each sternite, and most of last abdominal sternite, orange. Antennae four-fifths as long as body in male and two-thirds as long as body in female; prothorax strongly swollen at each side and on center of disc; elytra broadened preapically and rounded apically, impressed with numerous close, irregular punctures, and with three feeble longitudinal costae on each. Length 15.8–19.6 mm.; breadth at humeri 3.5–4.4.

Numerous specimens (Tsing-hua Univ.; Lingnan Nat. Hist. Mus.) were reared from apple at Kunming (Yunnan-fu), alt. 6000 feet, Yunnan Prov., S. W. China, May and June, 1940, by Mr. Ying-tou Mao.

Host plant: Pyrus malus[2] (Apple).

Distribution: Yunnan (Mouy-tse[1] and Kunming); Assam[2].

13. **Linda pratti** Pic

Linda pratti Pic, 1902, L'Echange 18 ("17"): 3[1]; Gressitt, 1942, Spec. Publ. Lingnan N. H. Surv. & Mus. 7: 10[2]; 1942, ibid. 8: 41.

Dull, clothed with a yellow and gray pubescence (much reduced on pale areas); black and testaceous; most of anterior portion of body and ventral surfaces testaceous: head broad, marked with black on antennal supports and behind eyes; vertex grooved; frons convex; eyes black; mandibles and apex of labrum dark; antennae not reaching elytral apices, attenuated, black, more or less testaceous at bases of fourth, fifth and sixth segments; prothorax entirely testaceous, short, margins sinuous, moderately swollen below middle of each side, behind which there is a groove, disc with a feeble longitudinal carina; scutellum broad, with testaceous pubescence; elytra black, slightly broader than prothorax, weakly constricted at middle, emarginate apically, with external angles prominent, surfaces with strong punctures subregularly arranged in longitudinal series, lacking distinct costae; wings dark; pygidium testaceous; ventral surfaces of body entirely testaceous; legs black with bases of femora, and sometimes bases of tibiae, more or less testaceous. Length 17 mm. (After Pic).

Distribution: N. Kiangsi (Kiukiang[1]); Kiangsu (Nanking[2]).

There is little in the original description of this form to separate it from *fraterna* and it may possibly prove to be a subspecies or synonym of the latter.

14. **Linda signaticornis** Schwarzer

Linda signaticornis Schw., 1925, Ent. Blätter 21: 154[1].

Head, prothorax, scutellum and ventral surfaces reddish yellow, except for a blackish area on part of metasternum; elytra and legs black with basal half of fourth segment reddish yellow and extreme base of fifth grayish. Head closely and strongly punctured; pronotum finely and sparsely punctured; both with fine grayish pubescence; scutellum truncate apically, transverse; elytra closely and subregularly punctured, obliquely truncate apically. Length 13 mm.

Several specimens (California Academy of Sciences) were taken in southern Formosa by the writer.

Distribution: Formosa[1] (Kosempo, Kankau, Sokutsu, Kusukusu).

15. **Linda tricostata** Gressitt, new species

Male.—Dorsal surfaces largely pale, antennae black and ventral surfaces pitchy: head and prothorax pale reddish ochraceous, mouthparts and prosternum pitchy black; antennae completely black, nonannulated; scutellum ochraceous; elytra orange testaceous, pitchy black on humeri; ventral surfaces largely pitchy, but with scattered areas of reddish brown or ochraceous; abdomen largely pitchy brown; legs blackish, anterior femur largely testaceous, the other femora pitchy. Dorsal surface clothed with thin pale pubescence and erect brownish to pitchy hairs; ventral surfaces with reddish to golden pubescence; antennae with close pitchy pubescence.

Head not quite as broad as prothorax, feebly convex in front, slightly concave between antennal insertions, grooved on vertex and occiput, rather coarsely and in large part closely punctured. Antennae not quite as long as body, moderately stout, most of segments slightly expanded ectoapically; scape not quite as long as third segment; third distinctly longer than fourth; fourth to tenth gradually decreasing in length, last cylindrical and suddenly acuminate distally. Prothorax nearly one-third again as broad as long, narrower at apex than at base, distinctly and evenly swollen at sides; disc with four feeble swellings; one on each side of center, one at center and one behind center; surface coarsely and in part closely punctured. Scutellum trapeziform, slightly swollen in center, truncate posteriorly. Elytra narrowest somewhat behind middle, apex of each gradually and obliquely narrowed externally and suddenly oblique internally, forming a rounded-obtuse angle; surface deeply, coarsely and closely punctured in about ten irregular rows divided in four areas by three costae, the punctures mostly separated by less than their diameters. Ventral surface somewhat heavily punctured at sides of hind thorax and first abdominal segment. Posterior femur reaching just beyond end of second abdominal sternite. Length 15.3 mm.; breadth 3.3.

Holotype, male (No. 58,339 U. S. Nat. Mus.) Kunming (Yunnan-fu), Yunnan Prov., S. W. China, Aug. 1, 1944, Dr. Liu Chung-lo (C. L. Liu) (Exper. No. 2218).

Differs from *L. nigroscutata* (Fairm.) in lacking the dark mark behind scutellum and in having the pronotum entirely pale.

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BOOK NOTICES

CHRONICA PALMARUM, P. LEPESME, Editor-in-Chief, PAUL LECHEVALIER, Publisher.

The review copy of *Les Insectes des Palmiers*, discussed above, was accompanied by an announcement of a new periodical under this title. The editor promises original studies of the botany of palms and their animal associates, miscellaneous observations and notes and bibliographic materials. The first volume is to appear in 1948. Articles on the classification of the palms, on the nematodes attacking palms and on insects inhabiting palms are mentioned as part of the contents of this volume. We extend our best wishes to the publisher and editor for the success of their venture. The subscription price is not mentioned.

—A. W. L.

LES INSECTES DES PALMIERS, by P. LEPESME with the assistance of J. BOURGOGNE, E. CAIRASCHI, R. PAULIAN and A. VILLIERS. 903 pages, 638 figures, 1947. Published by Paul Lechevalier, Paris. Price not given.

The value of this volume to North American entomologists is problematical since the distribution of palms in our area is so limited, but as a contribution to the entomology of warmer lands it is monumental. The reviewer knows next to nothing about palms, but he would hazard the opinion that this book is an exceedingly comprehensive survey of the insect enemies of these plants in all parts of the world.

The book includes three principal divisions. Part one is designated as a biological analysis of the synecology of the insects and palms, part two as a systematic study of the entomological fauna of the palms and part three is devoted to injurious insects, their damage and means of control.

Part one offers much interesting biological material. In part two the reviewer has found his own special group, the Hesperioidea, treated very informatively, hence he concludes that other taxonomists may find the survey useful. Part three is, of course, the most important section for economic purposes. It is the shortest part of the book, including only seventy pages. Spraying, dusting and mechanical measures of control are discussed, but the section leaves the impression that newer chemical agents for the control of insect pests have not yet been extensively used in this field. It should offer an important opportunity.

The book is well printed and the line cuts are excellent. Half-tones leave something to be desired. They are not especially poor but neither are they of really high quality.

In their general introduction the authors state that one of their number was vividly impressed with the lack of a general work on palm insects while on an entomological mission in equatorial Africa. They have abundantly corrected that lack in this excellent work.—A. W. L.